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Coastal and Hydraulics Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Boat Waves on Johnson Lake and Kenai River, Alaska

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Final report

Prepared for Alaska Department of Fish and Game
Habitat and Restoration and Sport Fisheries Divisions
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U.S. Army Engineer District, Alaska
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and Alaska Department of Natural Resources
Division of Parks and Outdoor Recreation
Soldotna, AK 99669

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Preface

The work reported herein was conducted for the U.S. Army Engineer District, Alaska, and the State of Alaska. The specific State of Alaska departments were the Alaska Department of Fish and Game (ADF&G), Habitat and Restoration and Sport Fisheries Divisions, and the Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation.

The field work was performed during July-August 2000 by personnel of U.S. Army Engineer Research and Development Center (ERDC), the State of Alaska, and the U.S. Army Engineer District, Alaska. From ERDC, Messrs. Terry Waller, Sam Varnell, Wallace Guy, and Dr. Stephen Maynord participated in the field studies. From the State of Alaska, participants were Mr. Lance Trasky, Mr. Dean Hughes, Ms. Chris Degernes, Mr. Doug Hill, Mr. John Bradshaw, Ms. Laurie Wood, and Ranger Bill Berkhahn. Volunteers for the State of Alaska Division of Parks and Outdoor Recreation participating in the study were Mr. Charles Carr, Ms. Lee Carr, and Mr. Matt Leone. From the U.S. Army Engineer District, Alaska, Dr. Robert Sanders participated in the study.

Boats and motors were provided for use by Mr. Peter Thompson of River and Sea Marine, Mr. John Cho of Riverbend Campground, and Mr. Daryl Aleckson who designed and built the low wake boat. David Morgenweck of River and Sea Marine detuned the motors from River and Sea Marine to allow testing at the different motor powers. Mr. Cho detuned the motor he provided for use in the study.

Thanks to Mr. Doug Hill, State of Alaska, operator of the boats during the weight and loading pattern studies and to Global Positioning System (GPS) operator Mr. Terry Waller. Mr. Dave Meyers of the U.S. Geological Survey staff headed up the team to measure water velocities and depths on the Kenai River.

The study was under the direction of Mr. Tom Richardson, Acting Director, CHL; Mr. Tom Pokrefke, Assistant Director, CHL; and Dr. Sandra K. Knight, Chief of the Navigation Branch, CHL. The report was written by Dr. Maynord.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
degrees (angle)	0.0175	radians
feet	0.3048	meters
horsepower (550 foot-pounds force per second)	745.6999	watts
inches	25.4	millimeters
miles (U.S. statute)	1.609347	kilometers
pounds (mass)	0.4535924	kilograms

Summary

Boat wave measurements were conducted on Johnson Lake and Kenai River to compare wave characteristics of five boats at Johnson Lake and two boats at Kenai River under a variety of loadings, speeds, distances, motor powers, and direction of travel. This study is part of an assessment of the effects of boat waves on bank erosion on the Kenai River. Separate studies will be needed to determine if the wave characteristics measured in this study are capable of producing damage to the banks of the Kenai River.

The Johnson Lake tests provided a semicontrolled environment where the influence of other factors on boat wave height was minimal. The Kenai River tests provided measurements that were significantly influenced by river flow and water level variations that were not present at Johnson Lake. A total of 596 tests were run on Johnson Lake and 284 tests on the Kenai River. Capacitance type wave gages developed at the U.S. Army Engineer Research and Development Center (ERDC) that use a wire conductor were used in the tests and were essential at the Kenai River tests due to the high flow velocities of 6-7 ft/sec.[1]

Boats used at Johnson Lake were the Willie Predator (WP), Koeffler (KF), Klamath (KL), Lowe (LW), and Aleckson. Only the WP and KF were used on the Kenai River and with only a six-person loading. The Aleckson is a boat being developed to produce less wake and was a minor part of the test program because it was not designed to be loaded to the same magnitude as the other boats. The WP and KL were V-hull boats and the KF and LW were flat bottomed. The WP and KF were 20 ft in length and the KL and LW were 16-ft in length. The V-hull boats were about 20 percent heavier than the flat-bottom boats having the same length. To determine the effects of boat loading, the 20-ft boats were loaded with three, four, and six people (165 lb each) and the 16-ft boats were loaded with three, four, and five people at Johnson Lake. Motor power effects were determined with 35 and 50 hp on the 20-ft boats (WP and KF) and 35 and 40 hp on the 16-ft boats (KL and LW). Boats were run at nine different distances ranging from 30 to 150 ft from the wave gages.

Two wave types were measured. MAXPOW was the wave height at the maximum power of the motor. MAXWAV was the maximum wave height produced by the boat which required runs at a range of speeds to determine the MAXWAV. At Johnson Lake, MAXPOW for all conditions ranged from 0.14 to

[1] A table of factors for converting non-SI units of measurement to SI units is presented on page ix.

0.99 ft. At Kenai River, the MAXPOW for all conditions ranged from 0.22 to 1.07 ft.

It cannot be overemphasized that Figure 1c is essential to understanding how changes in motor power and loading affect wave height and how the MAXWAV and MAXPOW are related. Figure 1c is a generic plot of boat wave height vs. boat speed which is alternately expressed as applied motor power. The four boats primarily used in this study have their own curve similar to Figure 1c. Changes in loading for a given hull will result in a curve that shifts up for increasing load and down for decreasing load. MAXWAV is at point A and occurred for most boats at a speed of about 9 mph. To the right of point A, a boat begins to plane or be on-step and wave height decreases. At full motor power, all Kenai River boats tested herein had MAXPOW to the right of point A. Figure 1c shows how different boats can be affected differently by changes in power or loading. A heavy boat could be at point B with a 35-hp motor and point C with a 50-hp motor. This change in power would result in a significant change in wave height. A light boat may be at point D with 35 hp and point E with 50 hp resulting in almost no change in wave height. Consequently, there are no simple rules that can be applied about the effects of a change in power for all boats. The ratio of motor power to weight was used in this study to combine the effects of motor power and weight in a curve similar to Figure 1c.

Subsequent paragraphs discuss wave changes in percentages such as a 10- or 20-percent reduction. Percentages are often the result of modest changes in the absolute magnitude of MAXPOW or MAXWAV. Summary and conclusions of the effects of different parameters follow.

Effect of Motor Power

Johnson Lake boats with 35-hp motors produced larger wave energy (Figure 46) and MAXPOW (Table 19a) than boats with 40- or 50-hp motors except for the Lowe which produced about equal wave heights and energies with the 40-hp motor. The WP at Johnson Lake produced a 20-percent reduction in MAXPOW with the 50-hp motor compared to the 35 hp. The Koeffler produced a 15 percent reduction with the 50-hp, the Klamath produced a 12-percent reduction with the 40 hp, and the Lowe produced no significant change with the 40-hp motor when compared to the 35 hp. On the Kenai River (Table 25), the WP with a 50-hp motor reduced MAXPOW by 12 percent when compared to a 35-hp motor. The KF produced no significant difference with the two motors. The largest difference due to power was the Willie Predator which is a result of the 35-hp motor producing a speed close to the speed causing the MAXWAV.

Effect of Boat

At Johnson Lake, the Willie Predator produced the largest wave energy (Figure 46) and MAXPOW (Table 19c). The average WP MAXPOW for a common power of 35 hp and common loadings of three and four people was 0.59 ft when averaged over all distances. The Koeffler and Klamath produced

similar MAXPOW and wave energies that were less than the Willie Predator. Average MAXPOW from the KF and KL for common power and loading was 0.34 and 0.39 ft, respectively. The Lowe produced the lowest wave height and energy of the boats tested having an average MAXPOW of 0.24 ft. At the Kenai River, the WP and KF MAXPOW for 35 hp (Table 25) averaged 0.61 and 0.39 ft, respectively, over all effects (six passengers only). The 50-hp Aleckson with three passengers produced wave height comparable to the average of waves from the Klamath with three passengers. The MAXWAV was similar for the WP and KL at Johnson Lake. All other boats were different. The WP MAXWAV averaged 22 percent greater than the KF MAXWAV at both Johnson Lake (Table 22) and the Kenai River (Table 28b) when averaged over both directions at Kenai River.

Effect of Hull Type

While other differences cannot be ruled out, hull type is the most apparent difference between two boat groups that exhibit differences in wave characteristics. With the existing 35-hp motors and equal number of passengers in the boats (three and four), the V-hull boats (WP&KL) produced a MAXPOW 66 percent greater than the flat-bottomed boats (KF&LW) because of the difference in hull shape and their greater total weight. With the existing 35-hp motors and equal total weight of the boats, the V-hull boat had an average MAXPOW 29 percent greater than the flat-bottomed boats. Nomographs of MAXPOW for the two hull types are given in Figures 33 and 34 and show that differences in hull type diminish with increasing power/weight when all the data are considered.

Effect of Direction of Boat on Kenai River

The MAXPOW was similar for upstream and downstream directions (Figures 41 and 42). The wave period was greater for upbound than downbound boats. The energy for the MAXPOW tests was greater for the upbound boats because of the greater period. The MAXWAV was larger for upstream boats with the WP upstream boat wave 24 percent larger than the downstream and the KF upstream boat wave 15 percent larger than the downstream.

Effect of Wave Type

The MAXWAV was larger than the MAXPOW for all boats. At Johnson Lake using common distances of 4-9, 35 hp, and average of all loads, the MAXWAV was 12, 60, 74, and 166 percent greater than the MAXPOW for the WP, KF, KL, and LW, respectively. At Kenai River using common distances 1-6, the MAXWAV was 38 and 66 percent greater than the MAXPOW 35 hp for the WP and KF, respectively, for upbound boats and 7 and 43 percent greater than downbound boats. Typical speed at which the MAXWAV occurred was about

9 mph relative to water. Wave period was higher for the MAXWAV than the MAXPOW, particularly for the upstream heading boats on the Kenai River.

Effect of Location (Lake or River)

MAXPOW averaged over all distances was similar at Johnson Lake and Kenai River. Using a loading of six passengers only, the MAXPOW at Johnson Lake averaged over all effects was 0.62 and 0.38 ft for the WP and KF, respectively. Using a loading of six passengers only, the MAXPOW at Kenai River averaged over all effects was 0.57 and 0.39 ft for the WP and KF, respectively. The lake and river were different regarding decay of MAXPOW as discussed subsequently under effects of distance. When averaged over common distances 4-6 and using six-passenger loading only, MAXWAV was larger at the Kenai River than at Johnson Lake for upstream runs and mixed results for the downstream runs. The WP had average MAXWAV of 0.65 ft at Johnson Lake vs. 0.55 ft for the downstream runs and 0.75 ft for the upstream runs. The KF had average MAXWAV of 0.49 ft at Johnson Lake versus 0.51 ft for the downstream runs and 0.62 ft for the upstream runs.

Effect of Load

All boats showed increasing MAXPOW with increasing load. The Willie Predator produced the greatest increase in MAXPOW, likely as a result of the larger loads resulting in speeds close to the MAXWAV speed. Based on Table 19b, the change in loading from heavy (six or five passengers) to light (three passengers) resulted in an average decrease in MAXPOW of 22 percent. The change in loading from heavy to medium (four passengers) resulted in an average decrease in MAXPOW of 10 percent. Loading changes produced only small changes in the MAXWAV tests (Figure 36).

Effect of Distance

All boats showed decreasing wave height with distance from the boat. The average slope (exponent) of the power function equation from the regression equations and Plates 8-26 for all MAXPOW tests is $X^{-0.40}$. At Kenai River the MAXPOW tests resulted in an average slope of $X^{-0.29}$ indicating a faster decay rate at Johnson Lake.

Summary of All Effects

Greatest reductions in wave heights and energies can be achieved by the following actions:

a. Encourage use of flat-bottomed boats.

b. Set minimum limits on motor power to weight ratio that depend on hull type. This can be achieved through greater motor power or lesser total boat weight.

c. Avoid continuous operation around 9 mph which is approximate boat speed at which MAXWAV occurs for all boats tested.

d. Recommendations for future studies are provided in Chapter 9, "Conclusions" in the main report.

1 Introduction

The Kenai River is an internationally known sport fishery and the large amount of boat activity on the river has raised concerns about bank erosion from the boat wakes. The study reported herein, which quantifies wave characteristics from different boats on the river, is part of a larger effort to determine bank erosion from boat wakes.

At the request of the State of Alaska and the U.S. Army Engineer District, Alaska, the U.S. Army Engineer Research and Development Center (ERDC) conducted field studies to determine wave characteristics from various boat/motor combinations used on the Kenai River, AK. The boats used in this study were 16-20 ft[1] in length and had motors ranging from 35 to 50 hp. The objectives of this study were to (a) compare waves from different boats, (b) compare the effects of different loads, motors, and distances, and (c) define the absolute magnitude of boat waves. One of the issues being addressed is the present regulation that limits motors used on the Kenai River to a maximum of 35 hp. This study compares waves from boats having 35 hp to the same boat having either a 40- or 50-hp motor under different load configurations, different distances, and different speeds. While not part of the original study objectives, findings on the effects of hull type are also presented in this report. These measurements are part of an assessment by the State of Alaska to define the influence of boat wakes on bank erosion. The field studies were conducted at Johnson Lake from July 23-28, 2000, and on the Kenai River from August 1-3, 2000, both sites near Soldotna, AK. The Johnson Lake studies provided a semicontrolled environment where waves could be measured without significant influence from other effects. The Kenai River wave measurements were significantly affected by other factors, primarily large river velocities and stage variations in the river, but provided wave measurements in the river of interest. The Kenai River tests were conducted between two fishing seasons, when boat activity was minimal, to avoid extraneous wave measurements. Two wave types were measured during the field tests. First, the wave height at the maximum power of the motor (full throttle) referred to as MAXPOW. Second, the maximum wave height (MAXWAV) of the boat was determined by measuring waves at a range of speeds and selecting the largest wave generated by the boat and motor combination. MAXPOW and MAXWAV should not be confused with the frequent references to maximum wave height which is the maximum wave height of a boat passage event and could be a MAXPOW, MAXWAV, or one of the tests run to find the MAXWAV.

[1] A table of factors for converting non-SI units of measurement to SI units is presented on page ix.

The wave data presented herein, MAXPOW and MAXWAV, could have alternately been presented as wave height versus boat speed since wave height and boat speed are highly correlated over a wide range of boat speeds. The primary objective of this study was determining MAXPOW with lesser emphasis on determining MAXWAV. Defining wave height over a wide range of speeds while conducting enough replicates to adequately determine MAXPOW and MAXWAV would have required a much larger number of tests.

The measurement and analysis of waves is a complex topic and much of the information presented in this report is necessary to document the technical concepts used in this study. For the layperson who is interested in what the wave heights are and how the boats compare, the following sections present the needed information:

a. Chapter 1, "Introduction" - Understand MAXPOW versus MAXWAV.

b. Chapter 2, "Wave Characteristics" - First two paragraphs and Figures 1 and 2. Particular attention should be paid to Figure 1c.

c. Chapter 3, "Description of Boats, Motors, and Loadings" Study and learn the meanings of WP, KF, KL, and LW.

d. Chapter 4, "Site Description, Ambient Conditions, and gage Orientation."

e. Chapter 6, "Experimental Procedure."

f. Chapter 7, "Presentation of Data" – Time-histories and test conditions and data only.

g. Chapter 9, "Conclusions."

After the layperson has finished the preceding sections, he or she may want to go back to Chapter 8, "Analysis of Data" to gain more insight.

The reader should note that this study is only part of an assessment of boat wave-induced bank erosion. Additional studies will have to be conducted to determine which, if any, of the wave characteristics presented herein, along with the level of boat traffic on the Kenai River, are capable of producing damage to the river banks.

2 Wave Characteristics

Waves are primarily characterized by their length, period, and height as shown in Figure 1a. The vertical axis in Figure 1a is the vertical position of the water level. The horizontal axis in Figure 1a can be either time or distance. The length L_w of a wave is the distance between one point on a wave to the same point on the next wave. The period of a wave T is the time it takes for two successive wave crests to pass a given point. The height of a wave H is defined herein as the vertical distance between a trough, or low point in the wave profile, and the following crest, which is the high point in the wave profile. The speed of the wave front is the celerity $C = L_w /T$. Water depth (d), if low enough, can have a significant impact on wave characteristics and depth effects are grouped by depth/wavelength (d/L_w). For d/L_w greater than 0.5, water depth has little impact on wave characteristics and this classification is referred to as deep water. For $d/L_w < 1/25$, wave speed is completely determined by water depth and this classification is referred to as shallow water. The region having $d/L_w = 1/25$ to ½ is referred to as transitional water. Data presented subsequently will show that depth effects were insignificant except for a small number of tests at the Kenai River. Wave theory is based on waves having a sinusoidal shape. Stumbo et al. (1999)[1] reports that for distances of "several vessel lengths away, the sinusoidal theory gives us a good basis for comparison of waves characteristics between various vessels."

The movement of a boat hull across the surface of a water body creates a variable pressure distribution along the length of the hull. The pressure variation generates a set of waves that move out away from the boat. The height of these waves depend on the vessel speed, the hull shape (particularly the bow), boat draft and trim and length, water depth, and distance from the boat. Wave heights are also strongly affected by boats whose power, in combination with hull shape, is sufficient to produce enough hydrodynamic lift to result in planing of the boat. Planing is also referred to as being on-step. The wave pattern consists of diverging and transverse waves as shown in Figure 1b. The angle between the axis of the boat and the diverging waves is β.

Figure 1c shows the general trend of maximum wave height versus boat speed (equivalent to applied power). Every boat hull and weight has its own curve like Figure 1c, but the shape and trends are similar for the typical Kenai River boats

[1] Stumbo, S., Fox, K., Dvorak, F., and Elliiot, L. (1999). "The prediction, measurement, and analysis of wake wash from marine vessels," *Marine Technology* 36(4), 248-260.

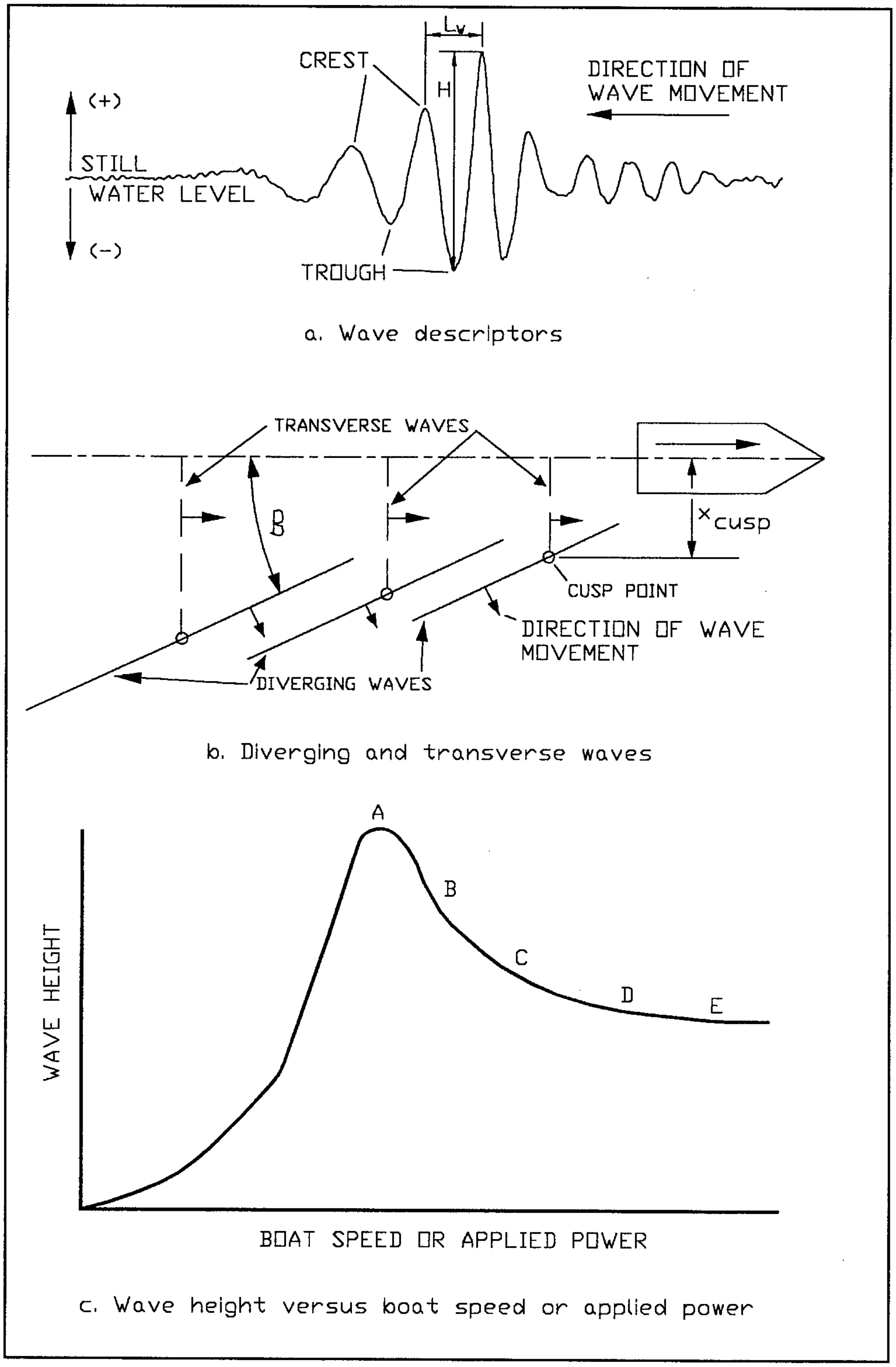

Figure 1. Boat wave characteristics

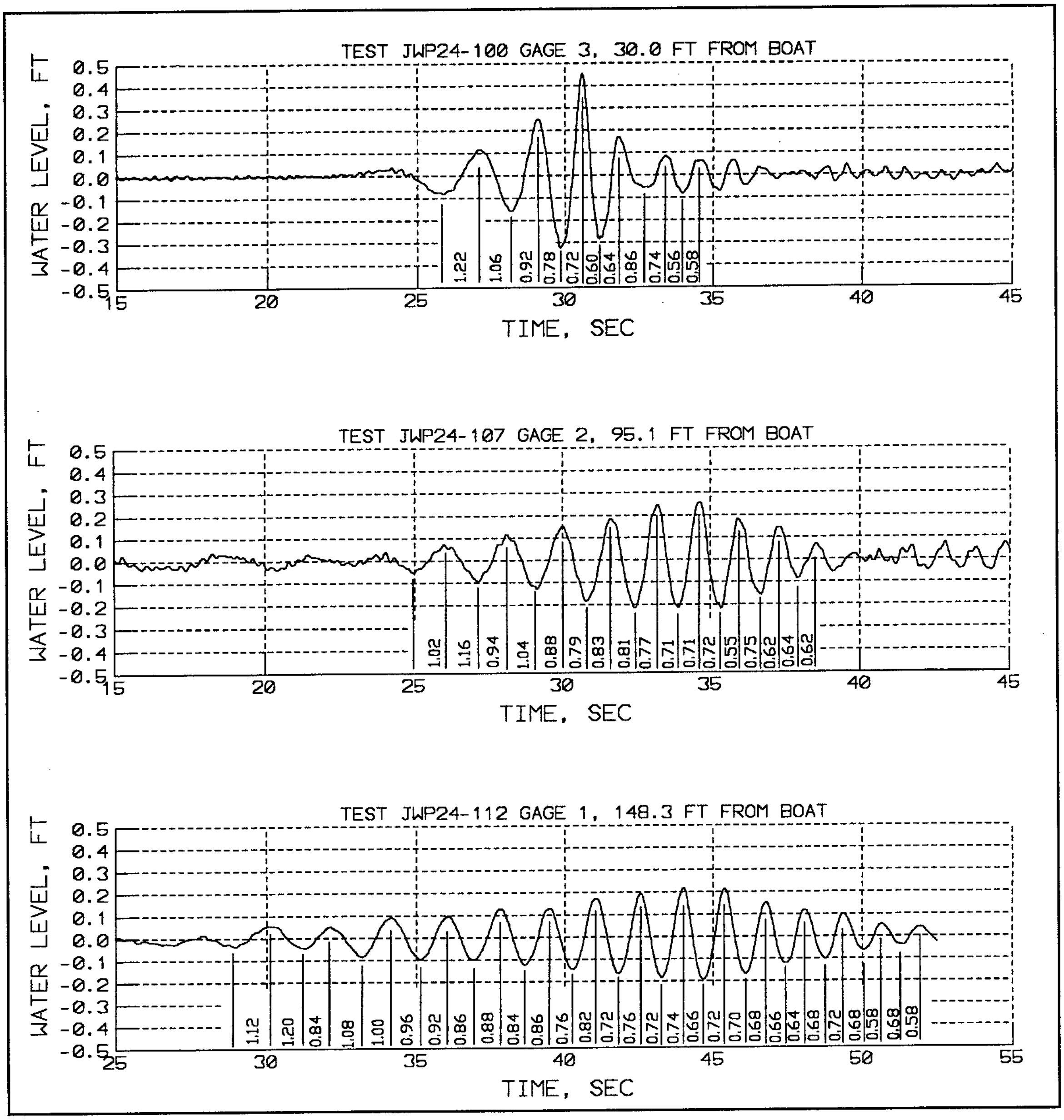

Figure 2. Time-histories of boat waves

used in this investigation. MAXWAV is located at point A. MAXPOW is located somewhere to the right of point A for the Kenai River boats used herein. Points B-E represent possible locations of MAXPOW that will be discussed later in this report.

Boat waves decay with distance from the boat as shown in Figure 2. Note that close to the boat, a few large waves are present. As distance increases from the boat, maximum wave height decreases and the number of waves increases. The change in wave period throughout a boat wave event is also shown in Figure 2.

The numbers along the lower part of each plot of water level are one half of the wave period measured in seconds.

Diverging waves form at the bow and stern of vessel at an angle β (Figure 1b) that depends on the vessel Froude number F_L based on boat length L, defined as

$$F_L = \frac{V}{\sqrt{gL}} \tag{1}$$

Where V is the boat speed, and g is the gravitational constant. According to Stumbo et al. (1999),[1] for large F_L and fine (streamlined) bow shapes, the angle β is less (around 4-10 deg) than for vessels having lesser F_L and more blunt hull forms (20-30 deg). Stumbo also reports that as β becomes smaller, so does wavelength and period. The transverse waves are normal to the axis of the vessel and tend to disappear at larger F_L. For all ships, the intersection of the diverging and transverse waves are called cusp points and are generally the locations of largest wave height. The angle of the cusp points with the axis of the vessel is about 19.5 deg. The lateral distance x_{cusp} (Figure 1b) of the cusp points from the sailing line is given by

$$x_{cusp} = \frac{1.21V^2(2N+1.5)}{g} \tag{2}$$

where N = 1,2,3.. is the number of the cusp point (1 being closest to the boat).

To compare the potential for damage from waves to streambanks, the energy in the wave train is frequently used for comparison. Wave energy (E) is equal to the kinetic energy plus the potential energy of the wave and is calculated for a single wave as energy per unit width of wave front as:

$$E = E_{kinetic} + E_{potential} = \frac{\rho g H^2 L_w}{16} + \frac{\rho g H^2 L_w}{16} = \frac{\rho g H^2 L_w}{8} \tag{3}$$

Where ρ is the water density and other parameters have been previously defined. Wavelength is determined from:

$$L_w = \frac{gT^2}{2\pi} \tanh\left(\frac{2\pi d}{L_w}\right) \tag{4}$$

Where π is a constant = 3.14, and tanh is the hyperbolic tangent defined for any variable x (in this case $x = 2\pi d/L_w$) as:

$$\tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}} \tag{5}$$

Where e = 2.718. Using the deepwater equation for $L_w = gT^2 / 2\pi$ results in

[1] Stumbo. op. cit. p.3.

$$E = \frac{\rho g^2 H^2 T^2}{16\pi} \tag{6}$$

Wave height and period for each wave in the event is used to compute the energy of each wave in the event. The energies from the individual waves are summed to determine the energy of all waves in one passage of the boat. The starting and ending points of the wave event are somewhat arbitrary in the wave energy calculations. The starting point posed no problem because it was obvious when the event started and any error in defining the start was small because the waves were small. The ending point was difficult because waves were reflecting off the banks and returning to the wave gages. The ending point was selected to prevent the reflected waves from being included in the calculations.

Another wave characteristic that is often related to shoreline damage is the maximum wave height because the thresholds for erosion may not be reached by a large number of small waves having a large amount of total energy. Erosion thresholds may be exceeded by a smaller number of large waves having lesser total energy.

3 Description of Boats, Motors, and Loadings

Five boat and motor combinations were used in the Johnson Lake tests and two of the five boat and motor combinations (Willie Predator and Koeffler) were used on the Kenai River tests. The following section includes the description and loading of the five boats.

Description

Klamath. The 16-ft open Klamath V-bottom boat (Figure 3) was a 1994 model with a 75-in. beam and weighed 980 lb. The motor was a 1994 Yamaha, model MHLS, 2-stroke, 40-hp engine with manual start, tiller control and a long shaft lower unit. The engine was equipped with a Yamaha 11-5/8-in. by 11-pitch Yamaha propeller. This motor was the same one used on the 16-ft Lowe Jon boat. The changeover from 35- to 40-hp was made by detuning the engine by carburetor adjustment.

Lowe. The 16-ft open Lowe flat-bottom Jon boat (Figure 4) was a 1994 model with 52-in. beam and weighed 700 lb. The motor was a 1994 Yamaha, model MHLS, 2-stroke, 40-hp engine with manual start, tiller control and a long shaft lower unit. The engine was equipped with a Yamaha 11-5/8-in. by 11-pitch Yamaha propeller. This motor was the same one used on the 16-ft Klamath boat. The changeover from 35- to 40-hp was made by detuning the engine by carburetor adjustment.

Koeffler. The 20-ft open Koeffler flat-bottom sled (Figure 5) was a 1997 model with a 95-in. beam and weighed 1,660 lb. The motor was a 1997 Yamaha, 4-stroke, 50-hp engine with electric start, remote steering control, a long shaft lower unit and power tilt and trim. The engine was equipped with a Yamaha 13-5/8-in. by 13-pitch Yamaha propeller. The changeover from 35- to 50-hp was made by detuning the engine by carburetor adjustment.

Willie Predator. The 20-ft open Willie Predator V-bottom boat (Figure 6) was a 1997 model with an 84-in. beam and weighed 2,180 lb. The motor was a 1999 Honda, 4-stroke, 50-hp engine with electric start, tiller control, a long shaft lower unit, and power tilt and trim. The engine was equipped with a Yamaha

Figure 3. Klamath V-bottom boat

Figure 4. Lowe flat-bottom boat

11-5/8-in. by 11-pitch Yamaha propeller. The changeover from 35- to 50-hp was made by detuning the engine by carburetor adjustment.

Aleckson. The 16-ft Aleckson boat (Figure 7) was constructed to make a smaller boat wake by using a pontoon design with an open hull. The motor was a 2000 Honda, 4-stroke, 50-hp engine with electric start, tiller control, a long shaft lower unit and power tilt and trim. The engine was equipped with a Yamaha 11-5/8-in. by 11-pitch Yamaha propeller. The Aleckson boat was still in development at the time of these tests and only a limited series of MAXPOW tests were run with loadings of one and three people. The performance of the boat with a three-person loading suggested the boat was not designed for a five-person loading. Since loadings similar to the other boats could not be run, the Aleckson results are presented only to document the tests that were conducted. Limited comparisons will be made between the three-person Aleckson boat and other boats.

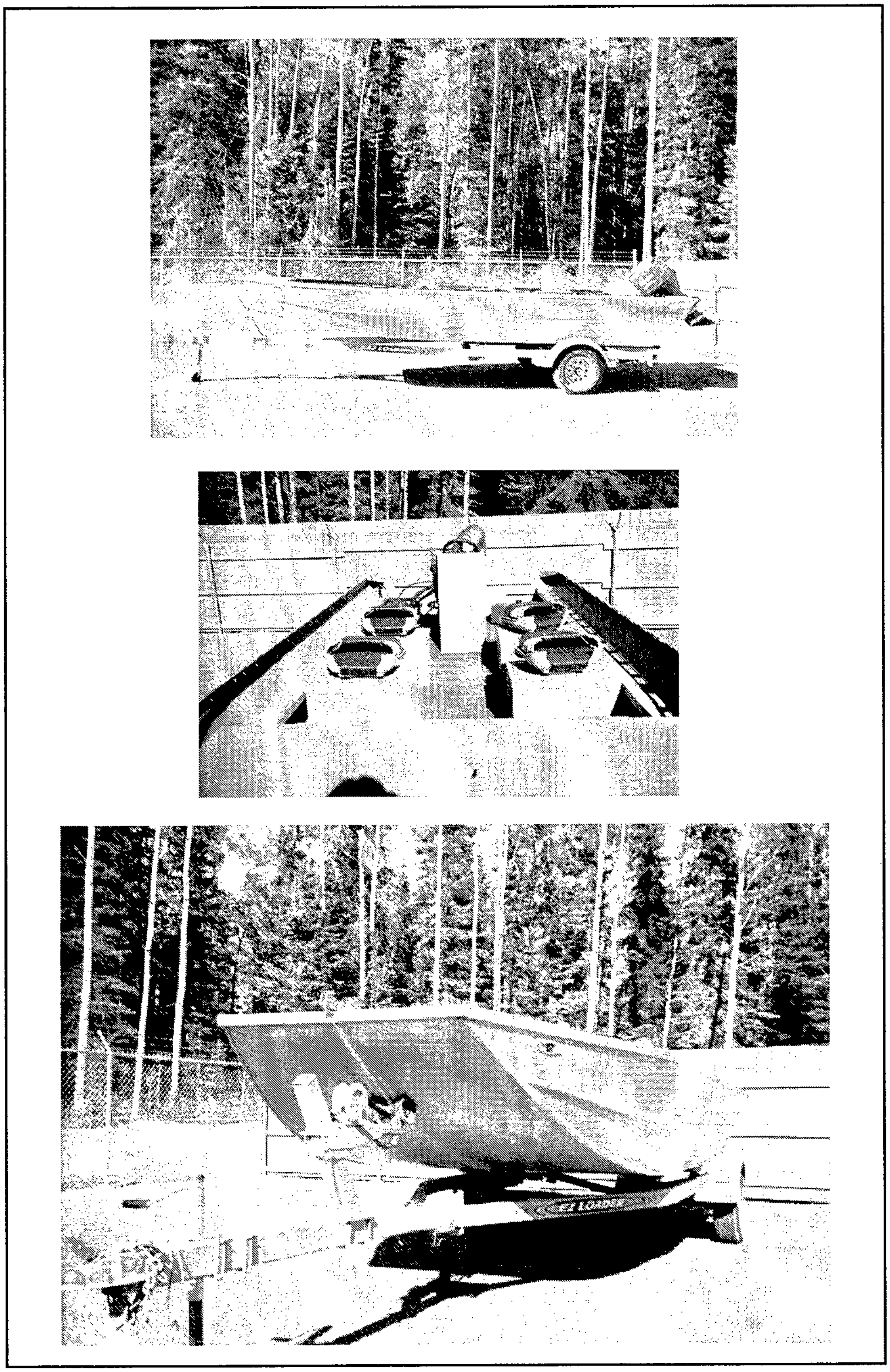

Figure 5. Koeffler flat-bottom sled

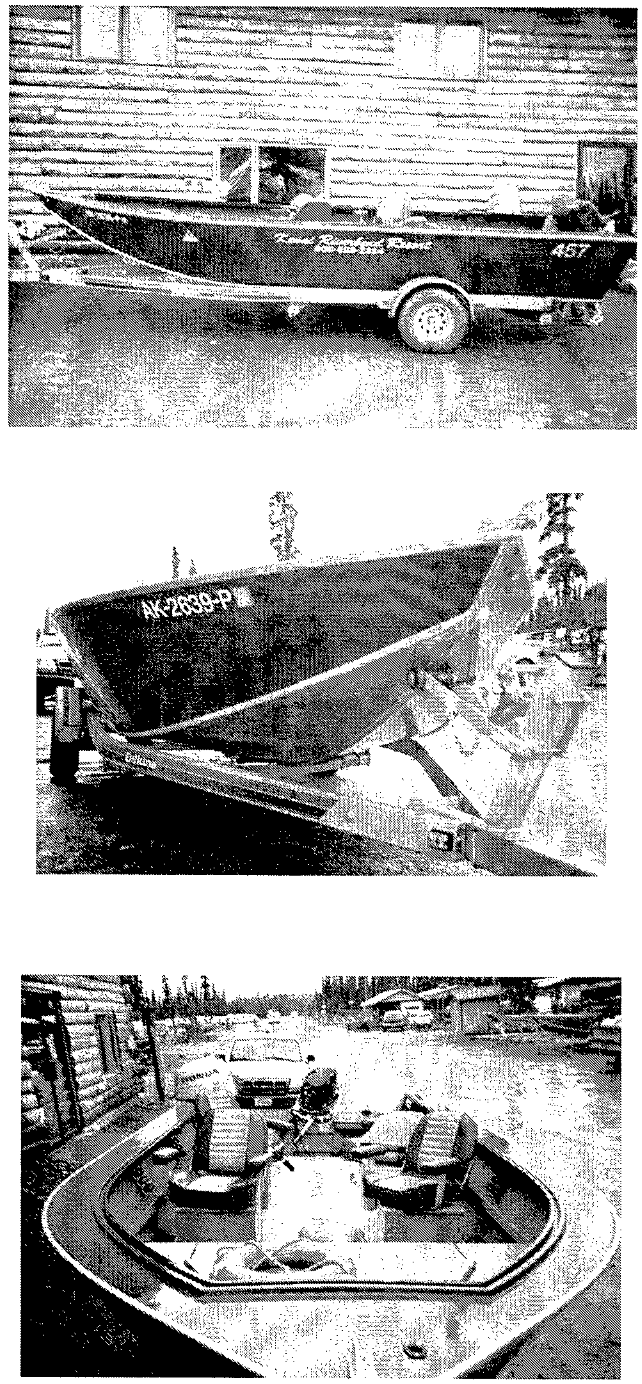

Figure 6. Willie Predator V-bottom boat

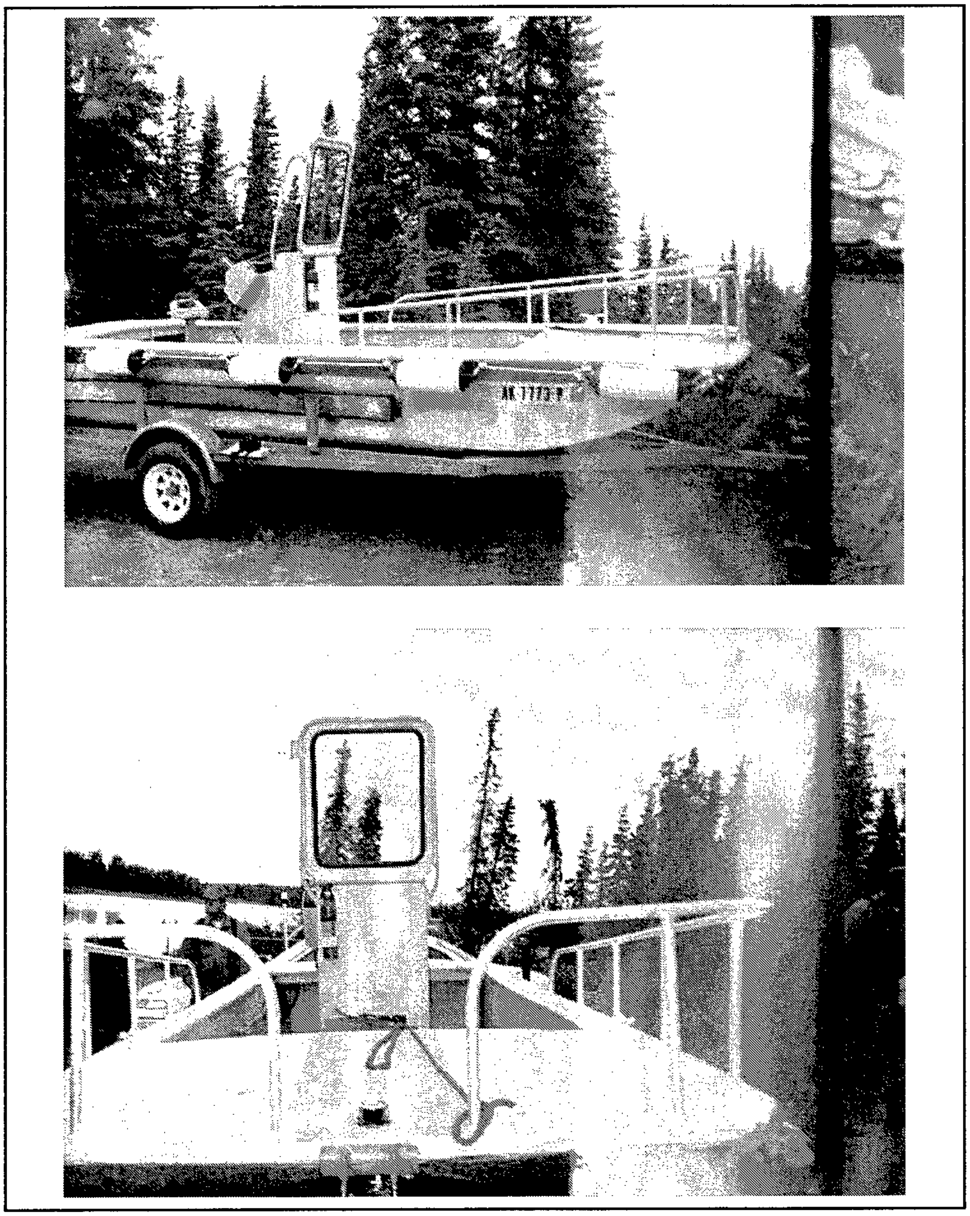

Figure 7. Aleckson boat

Weight and Loading Pattern

The loading pattern for each boat is shown in Figure 8. The numbers refer to placement of passengers (including operator) for that loading. The pattern for each loading was considered to be the most likely for that number of passengers. Each additional person, beyond the boat operator and the boat speed recorder, was represented by 165 lb of sandbags. The boat operator weighed 165 lb, and the operator of the Global Positioning System (GPS) to obtain boat speed weighed 200 lb. Total sand bag weight was adjusted to account for the difference of the operating personnel weight from 165 lb. The loading pattern resulted in differing trim and planing of the boat for the different loadings.

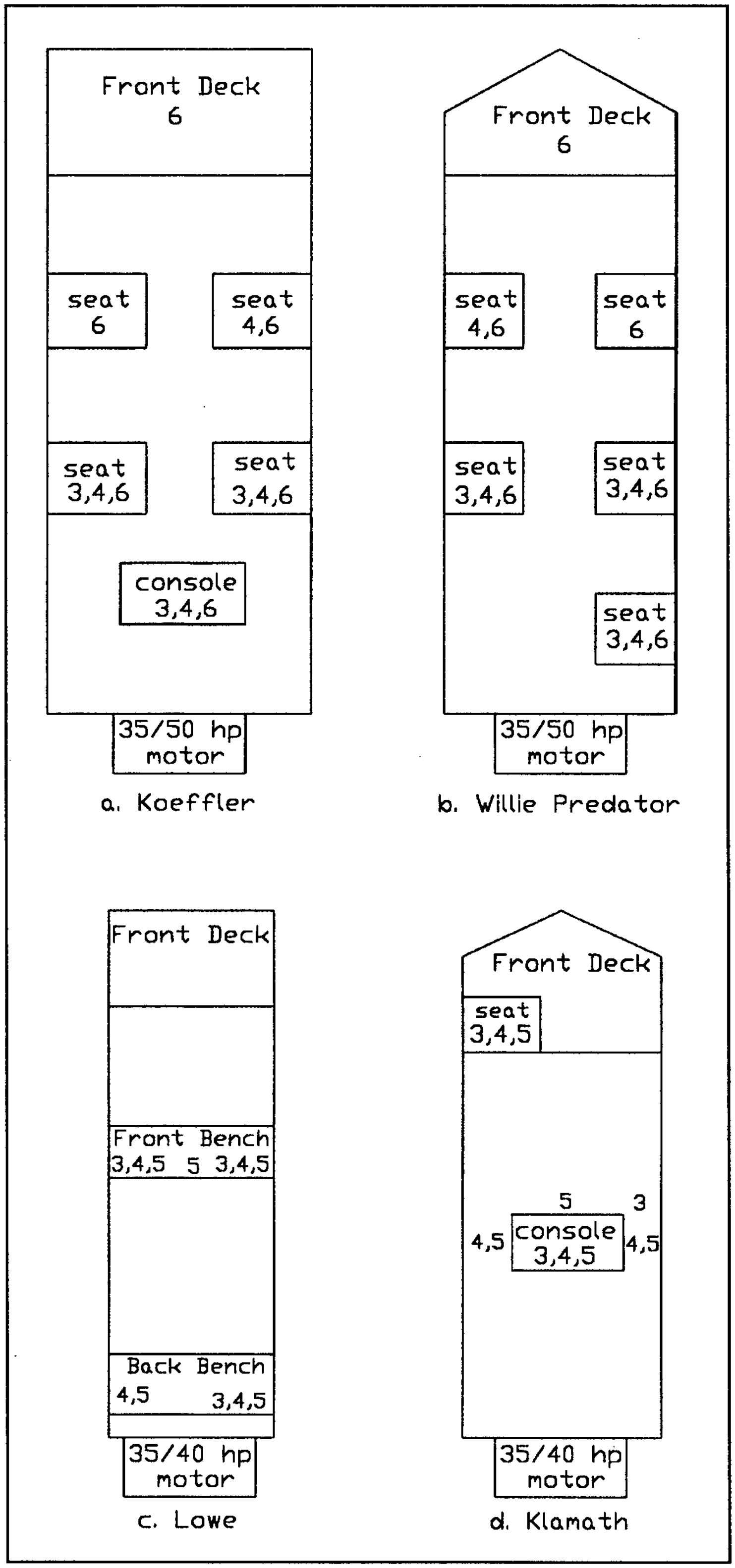

Figure 8. Loading pattern

Stumbo et al. (1999)[1] reports significant effects of trim on wave height from ferries.

With the passenger loadings, total boat weight was as follows:

Klamath: 3 people= 1,475 lb, 4 people = 1,640 lb, 5 people = 1,805 lb

Lowe: 3 people= 1,195 lb, 4 people = 1,360 lb, 5 people = 1,525 lb

Koeffler: 3 people= 2,155 lb, 4 people = 2,320 lb, 6 people = 2,650 lb

Willie Predator: 3 people= 2,675 lb, 4 people = 2,840 lb, 6 people = 3,170 lb

The weight of the Aleckson was not determined.

[1] Stumbo. op. cit. p. 3.

4 Site Description, Ambient Conditions, and Gage Orientation

Johnson Lake

Johnson Lake (Figure 9) is located 15 miles south of Soldotna, AK, and is an 85-acre lake having the shape of an hourglass. The lake had several features which were desirable for boat wave measurement in a controlled environment. First, the lake was small enough to minimize wind wave problems. Wind waves of sufficient magnitude would have made it difficult to separate the boat waves from the measured data. Second, the lake was large enough to avoid problems from reflection of boat waves off shorelines. Third, the lake perimeter was lined with aquatic vegetation which dampened wave activity and minimized waiting times between tests. Fourth, no other motorized boats were allowed on the lake.

The gage layout, sailing line layout, and water depths are shown in Figure 10. The gages at both Johnson Lake and Kenai River were intentionally placed in water depths large enough to classify as deep water conditions as described in Chapter 2, "Wave Characteristics." This was done to eliminate depth effects when comparing wave characteristics. The gage layout and numbering was the same at both Johnson Lake and Kenai River. All boats on Johnson Lake were run in a southwest direction. The different sailing lines provided different distances from the wave gages.

Kenai River

The Kenai River site is shown on Figure 11 and is on the left descending bank of a relatively mild bend near river mile 32. The layout of gages and sailing lines is shown in Figure 12. The staff from U.S. Geological Survey (USGS), lead by Dave Meyers, measured water velocities and depths at the Kenai River site during the three days of tests on the river as shown in Table 1. Surface velocities in the river at the gages were up to 6 ft/sec. The USGS set a reference stake at the edge of the river from which river stages were measured. River stage at the Kenai River site rose 0.49 ft from 1030 on August 1 to 0800 on August 4. This small change in depth at the sailing lines of about 7 percent had no significant effect on the wave characteristics.

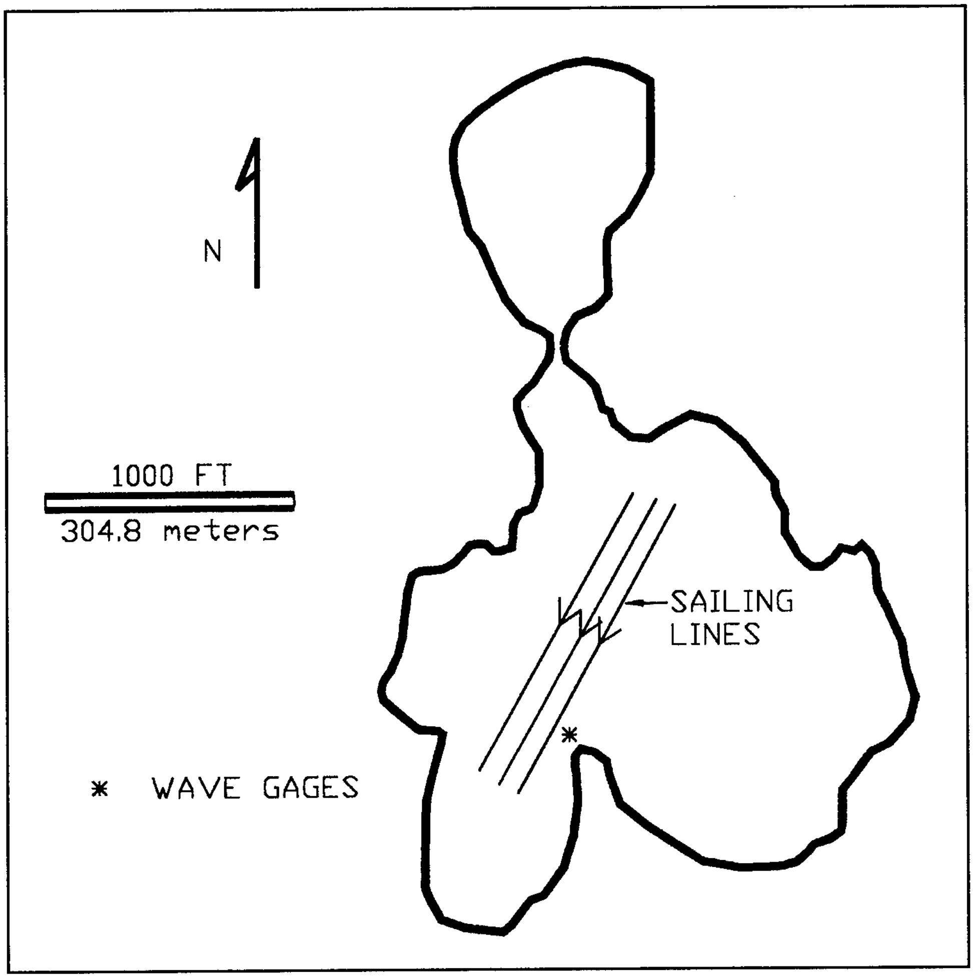

Figure 9. Schematic of Johnson Lake

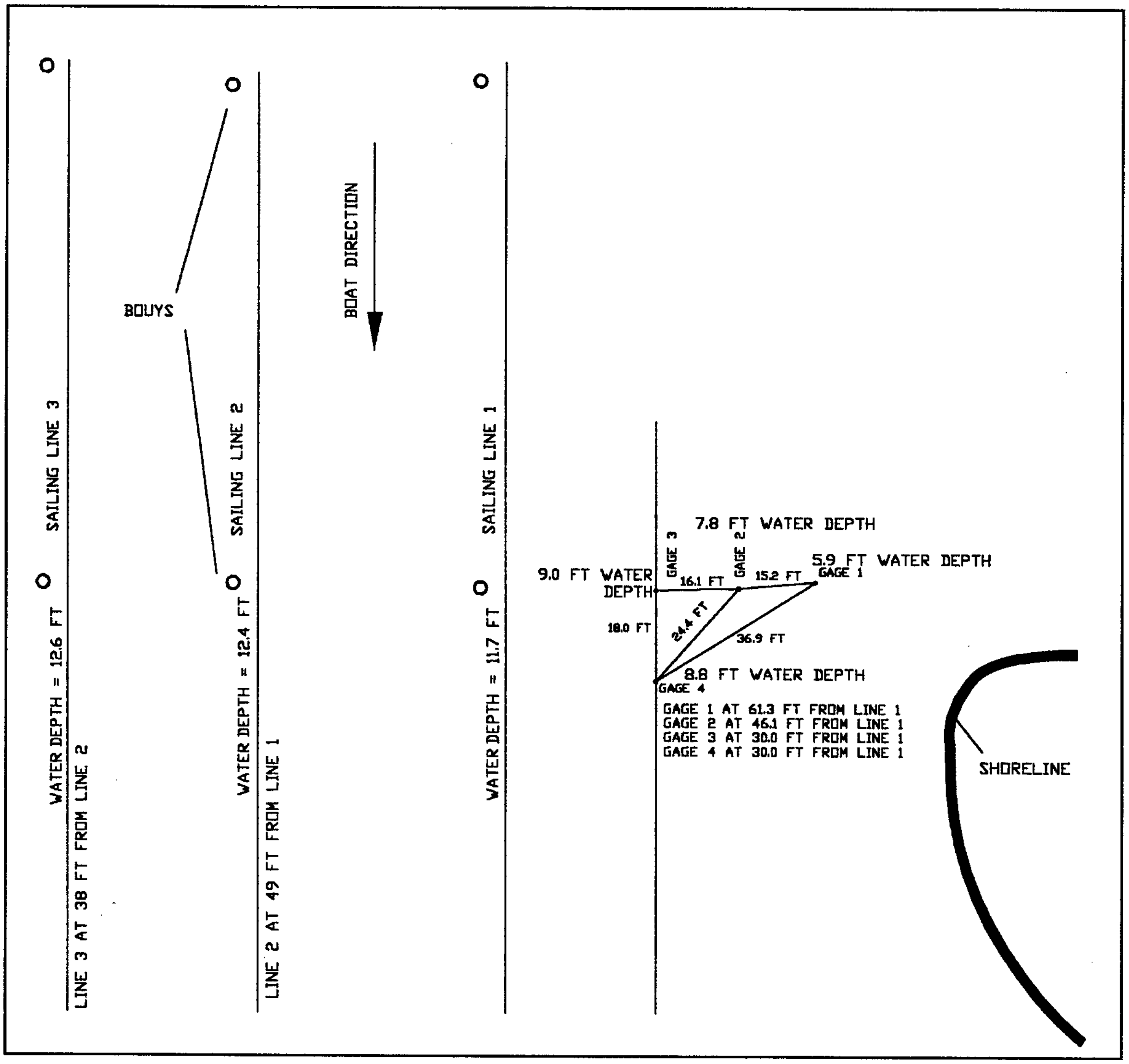

Figure 10. Schematic of gage and sailing line locations at Johnson Lake

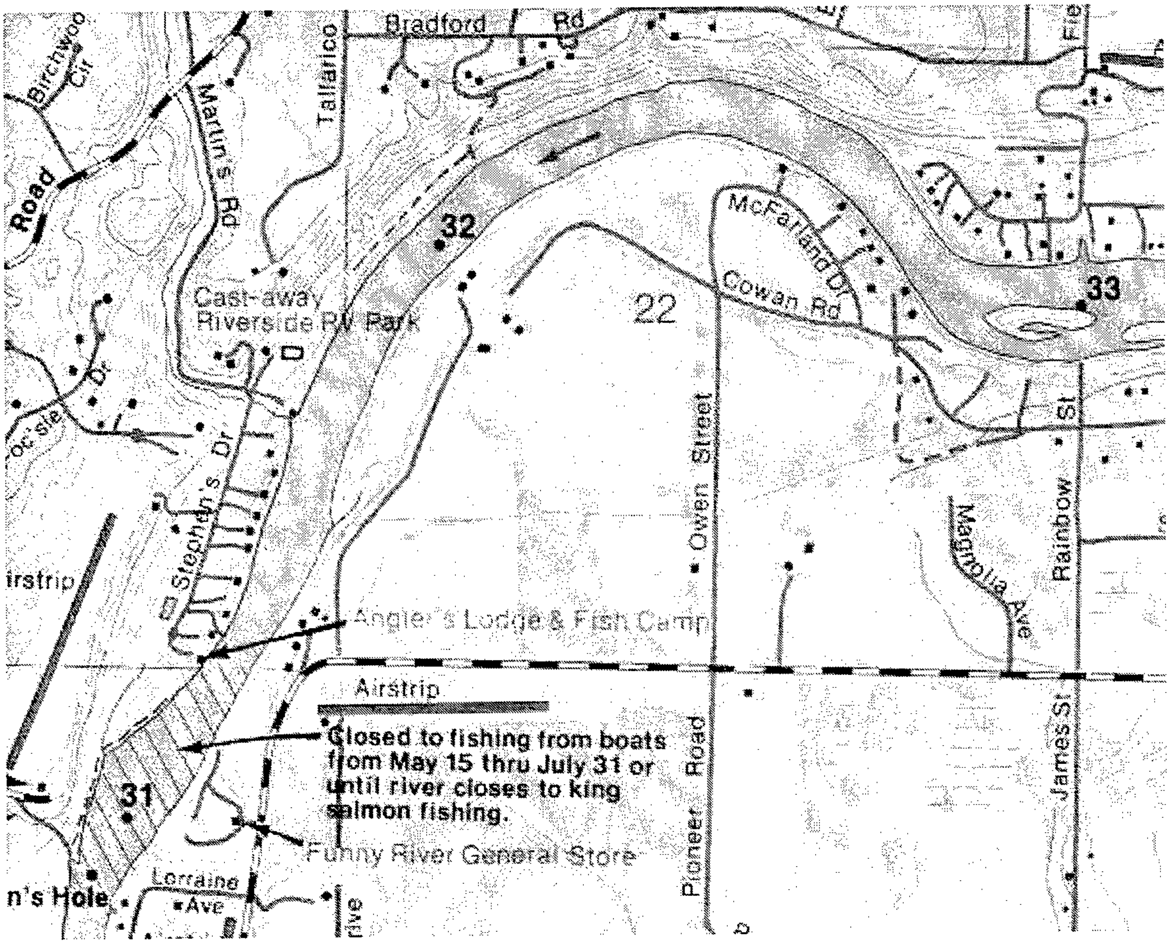

Figure 11. Site map of Kenai River measurement location (near river mile 32 on left descending bank)

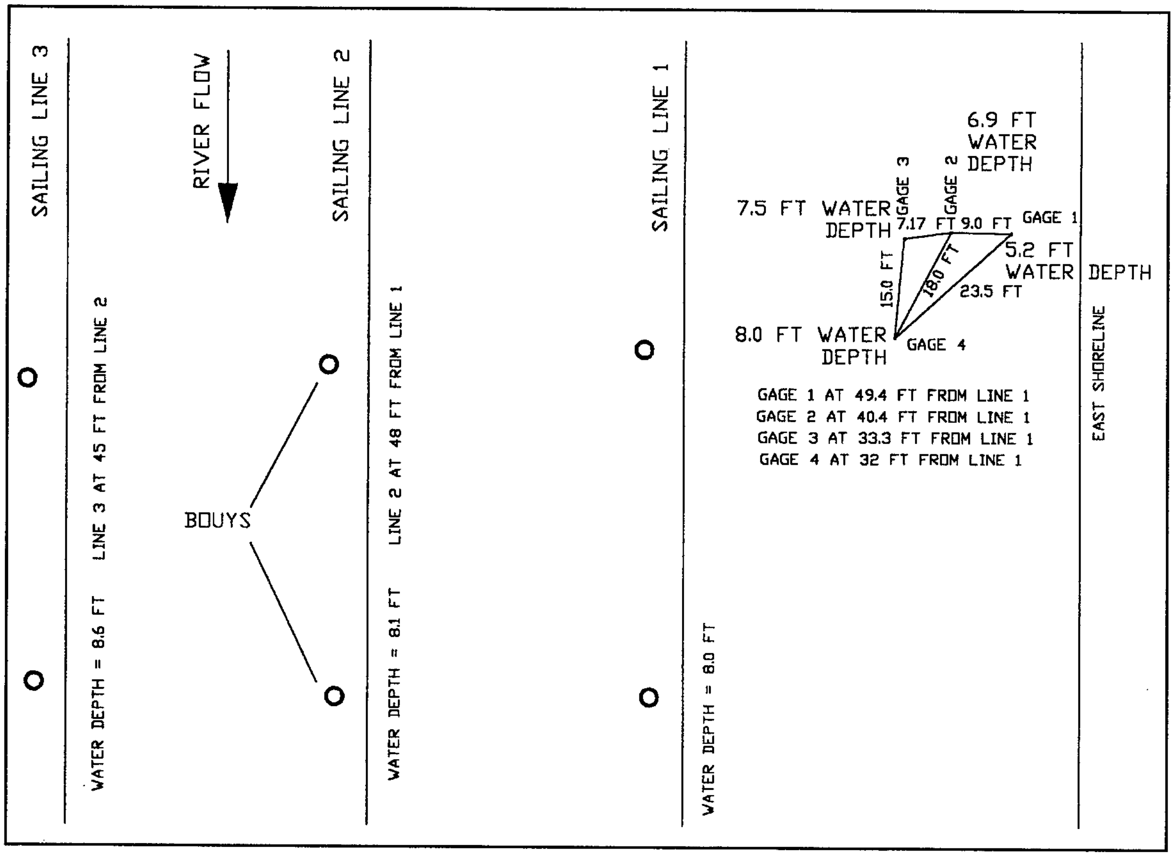

Figure 12. Schematic of gage and sailing line locations at Kenai River

5 Instrumentation

Wave Gage Stands

The wave gage stands are shown in a schematic in Figure 13 and were designed to have a small area normal to the flow to reduce drag in the river. The legs were adjustable to handle uneven bottom bathymetry and the three legs were designed to be close to the bottom in the area of lowest velocity in the river thereby resulting in the lowest drag on the stand. The river water velocities were much larger than anticipated and the gages had to be restrained by cables tied upstream to prevent them from being washed downstream by the current. A cable was attached to the upstream leg of the stand and the other end was attached to a large piece of steel about 25 ft upstream of the gage stand. Another cable was attached to the piece of steel and tied to a tree on the shoreline about 150 ft upstream of the piece of steel. The piece of steel was deemed necessary to reduce the tendency of the cable, because it was at an angle to the river currents, to pull the gages toward the bank. Deploying this arrangement was extremely difficult and should not be attempted without people who have experience in field work and skilled boat drivers are an essential element. This cabling arrangement was used for gages 1-3. Gage 4 was restrained by attaching a cable from the lower part of the vertical staff of gage 3 to the upstream leg of gage 4. Precise placement of gages in desired locations is not possible in this type of high energy environment. In addition, the gages could not be spaced as far apart as the gages at Johnson Lake because the upstream restraining cables pulled the wave gage stands toward the bank when attempts were made to place them farther out in the river. While it was not possible to place the gages at desired locations, once in place, accurate measurements were made of their position relative to the sailing line of the boats.

Data Acquisition

General

The wave gages used in this study were designed and built at ERDC and have been used in scale model testing for 10-15 years. These gages have demonstrated repeatable calibrations, stability with temperature, and accurate enough to use in scale model tests. The wave gage system was based on capacitive sensor techniques and consist of four main parts: a) wave staff, b) oscillator card, c) interface card, and d) frequency to voltage converter card.

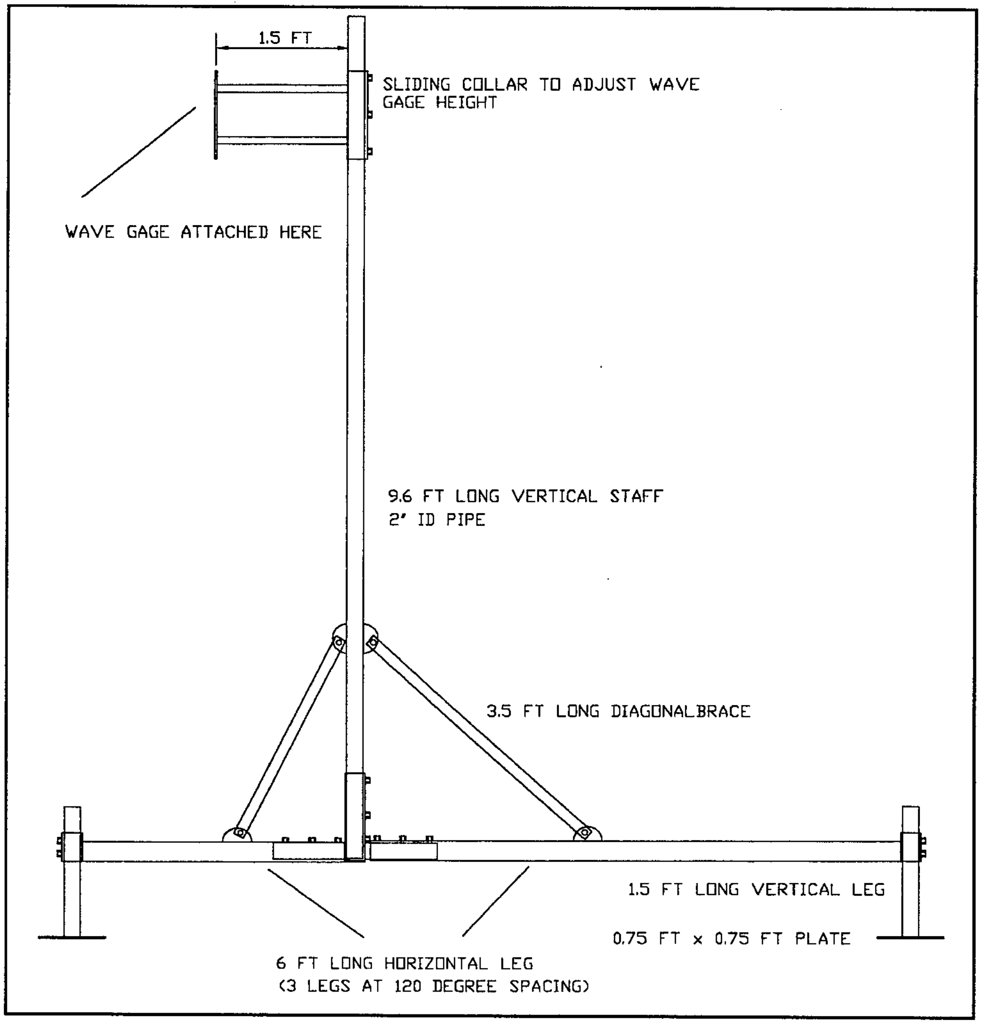

Figure 13. Wave gage stand

Wave staff

The wave staff (Figure 14) consists of a 30-in.-long insulated wire drawn taut in a stainless steel tube bow. The insulation of the wire serves as a capacitor between the inner conductor and ground. The capacitance between the conductor and ground varies linearly with changes in water-surface elevation. The insulation has to be uniform along the wire's length and free of holes. The conductor of the wire is connected directly to a variable oscillator on the oscillator card mounted in the plastic cylinder on the top of the wave staff to minimize stray capacitance that could affect frequency stability. The use of wire type capacitance wave staffs proved to be essential in the Kenai River tests. At Johnson Lake, pressure cells or one of the various types of rod type capacitance gages could have been used successfully. At Kenai River, the 6 ft/sec river velocity caused a piling up of water of about 1.5 in. on the one-fourth-in.-diameter rod (also called the bow) holding the capacitance wire. The piling up of water on the wire was negligible but would have been a serious problem with any of the commercially available rod type capacitance gages. One modification that should be considered with any future tests in currents would be the addition of a dummy wire about 12 in.

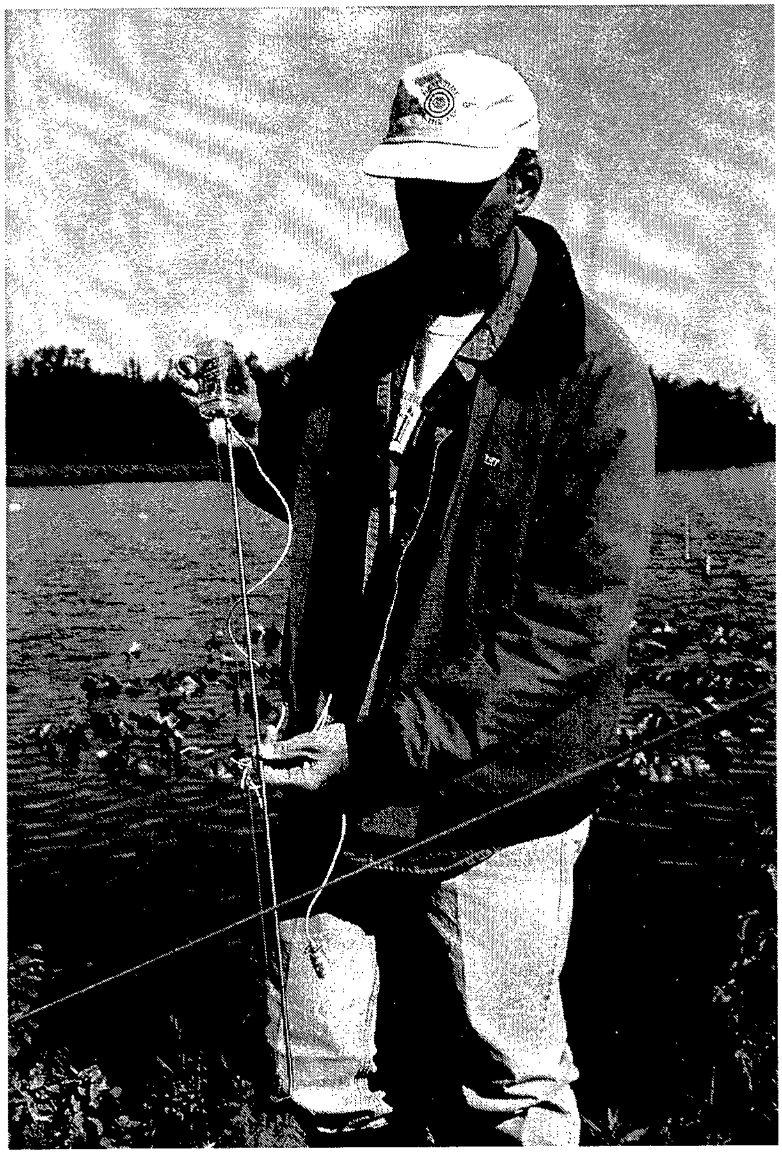

Figure 14. Wave gage

directly upstream of the capacitance wire to catch and deflect any debris in the river. Gages in the river had to be frequently cleaned at the Kenai River site because of various types of vegetation collecting on the gages and the wire broke on three different occasions which may have been the result of debris impact.

Oscillator card

The oscillator card consists of two identical oscillators, a frequency divider, and an optical isolator line driver. The oscillator card produces a frequency-modulated output proportional to water-surface elevation.

Interface card

The interface card has an isolated 12-volt dc-dc voltage converter and a test point for monitoring the output of the oscillator card.

Frequency-to-voltage card

The frequency-to-voltage card accepts the frequency-modulated signal from the oscillator card via the interface card and converts it to an analog voltage output that is compatible with the analog-to-digital converter in the portable computer system where it is recorded and stored for analysis at a later time.

The wave gage system is designed for maximum isolation between its own parts, the data acquisition system, and other electronic equipment. Each oscillator card is isolated from all others by means of an isolated dc-to-dc converter. The oscillator card output also features isolation in its output circuit with an optical isolator and a current output. This isolation produces a high signal-to-noise ratio, which allows very high signal resolution and accuracy. This wave gage system has been in use for quite some time and all data collected have shown very high stability and consistency. The four channels of wave data were recorded through a 16-channel, 16-bit resolution analog-to-digital card on a 166-MHz portable computer with a 26 gigabyte hard drive. All data was backed up on compact discs (CD). The data was recorded at 50 samples per sec per channel for the duration of the test. The analog input signals were conditioned with a four-pole, 10-hertz, low-pass active filter on the frequency-to-voltage card. The data acquisition system was powered by a 5-kW portable generator and a 1-kW battery backup uninterruptable power system. This provided the opportunity to service the generator and still remain on line for data acquisition and analysis. It also allowed for the continuation of data acquisition and analysis in the event of a power failure.

Calibration

The capacitance gages were calibrated at numerous times throughout the field measurements as shown in Table 2. Calibration R#-C10 was an inplace calibration to insure the calibration while in the river matched the tank calibrations done on the river bank. Good agreement was found between the two calibrations. A second order polynomial equation has been found to fit the calibration data in previous studies using these same type capacitance gages and was used in this study. Calibration for each gage was as follows:

a. Gage 1: The equation used for all tests is based on calibrations L1-C1, L1-C2, L1-C3, L1-C4, R1-C1, and R1-C11 and is shown in Plate 1

b. Gage 2: The equation used for all tests is based on calibrations L2-C1, L2-C2, L2-C3, L2-C4, R2-C1, and R2-C11 and is shown in Plate 2.

c. Gage 3: The equation used for all tests until 1300 on August 1 is based on calibrations L3-C1, L3-C2, L3-C3, L3-C4, and R3-C1 and is shown in

Plate 3. The gage wire broke at 1300 hr on August 1 and was replaced. The equation for tests from 1300 on August 1 to the end of testing on August 1 was based on calibrations R3-C1B and R3-C2 and is shown in Plate 4. Gage 3 wire broke again before start of testing on August 2. The wire was replaced and the equation for tests from beginning of tests on August 2 to end of all tests on August 3 was based on calibrations R3-C2B, R3-C3, and R3-C11 and is shown in Plate 5.

d. Gage 4: The equation used for all tests on Johnson Lake is based on calibrations L4-C1, L4-C2, L4-C3, L4-C4, and R4-C1 and is shown in Plate 6. The next calibration of gage 4 was on the morning of August 3. Condensation was observed inside the gage and the calibration R4-C2 did not match R4-C1. This cast doubt on gage 4 data from the beginning of testing on August 1 to the end of testing on August 2 because it could not confirmed when the problem occurred. Of all the gages to lose, this was the most fortunate because gage 4 was primarily for wave angle determination. The timing of the waves is not suspect, only the magnitude. Consequently gage 4 can still be used for angle determination but will not be used for magnitude for all tests on August 1 and August 2. A new gage was deployed and calibrated as R4-C4 at the beginning of August 3. The wire broke at 1200 hr and was repaired and calibrated as R4-C5. The equation used for all tests on August 3 was based on calibrations R4-C4, R4-C5, and R4-C11 and is shown in Plate 7.

6 Experimental Procedure

At Johnson Lake, five replicates were run for each combination of boat, motor, loading, and sailing line with eight replicates run at the Kenai River for each combination of boat, motor, direction (upstream and downstream), and sailing line. The boat was loaded as described in Chapter 3. Buoys were set to establish the sailing lines at a known distance and angle relative to the wave gages (Figures 10 and 12). Speed was measured by a radar gun and/or GPS receiver as shown in the data tables. The radar gun was used from a separate boat positioned along the sailing line and measured boat speed to the nearest 1.0 mph. The GPS unit was onboard the test vessel and speed was recorded to the nearest 0.1 mph. For the maximum power wave height (MAXPOW) tests, the boat was operated with a wide open throttle and started far enough from the gages to allow the boat to reach a constant speed. For the maximum wave height (MAXWAV) tests, the boat was started much closer to the gages because it required a lesser distance to achieve a constant speed with the lower speeds in the MAXWAV tests. Tests were numbered with J or K as the first letter for Johnson Lake or Kenai River. The next two letters were the boat with WP = Willie Predator, KL = Klamath, KF = Koeffler, LW = Lowe, and NW = Aleckson. The next number was the day of the month. The last number after the hyphen was the sequence of tests with test 1 being the first test of the day. At the Kenai River site, all even numbered tests were upbound and all downbound tests were odd. The MAXPOW tests were easy to run and speeds were relatively constant from test to test as shown in the data tables. The MAXWAV tests caused the boat operators great difficulty because the maximum wave making speed was difficult to maintain, possibly because (a) it is difficult to maintain a constant motor rpm with a partial throttle and (b) it is just before the speed at which the boat begins to rise up and plane or be on step. The boat operator reported that the motor used on the Klamath and Lowe was particularly difficult to maintain a constant speed for the MAXWAV tests. The MAXWAV tests were run by running single tests at speeds in roughly 0.5 to 1.0 mph increments. Maximum wave height was determined for all four gages for the single test at each speed. The speed producing the maximum wave height was used for four more tests on Johnson Lake (to provide five replicates) and seven more tests at Kenai River (to provide eight replicates).

7 Presentation of Data

Filtering

A filter, whether on a water faucet or an automobile gas line, is used to remove unwanted substances. Filters are also used with experimental data to remove information that has nothing to do with the problem being studied. The USGS data provided in Table 1 represent an average velocity over a given time period. All fluctuations in velocity have been filtered out by averaging the velocity readings over a given time period. At the outset of this study, it was anticipated that filtering of the experimental data would be used to remove some of the variations caused by factors not related to the boat wave such as wind waves, river stage variations, and the effects of river currents. Filtering of experimental data is done by damping oscillations of a given frequency while not affecting oscillations of other frequencies. The critical issue is that one cannot dampen oscillations that are part of the problem being studied. Average periods of the boat waves varied from about 1 to 2 sec or average frequencies from about 0.5 to 1 Hz (1Hz = 1 cycle/sec). Near the boat where the waves may not be sinusoidal, the waves may contain data at frequencies higher than the average frequency. A Fast Fourier Transform (FFT) filter from (Press et al. 1992)[1] was used to filter the data. Figure 15 shows Test JWP24-41 (Johnson Lake, Willie Predator, July 24, 41st test of the day) which has the unfiltered data and the FFT filtered data based on 0.05 to 2.0 Hz for gage 3 with the boat at the closest sailing line. This test was a 35-hp MAXPOW test for the Willie Predator with six passengers at a speed of 15 mph. The Johnson Lake test was selected for this comparison because other parameters had little effect on the wave profile. The 0.05 Hz filter only affects long period oscillations occurring much slower than the boat waves. The upper limit filter (2 Hz in this case) is what we are interested in because it is essential that the selected filter must not affect the boat wave. If the data is filtered too much, maximum wave height will be reduced by the dampening of the filter. Note that at around 27.5 sec, the 2 Hz filter is smoothing out some of the ambient wind wave oscillations which is the desired result. However, also note that the trough at 34.2 sec and the crest at 34.9 sec are affected by filtering and would indicate a lesser maximum wave height compared to the unfiltered data. This problem is more apparent at the troughs at 37 and 38.5 sec. Figure 15 shows that if we filter out the ambient fluctuations, we will also affect the boat wave results. Figure 16 shows the same test using a FFT filter

[1] Press, W. H., Flannery, B. P., Teukolsky, S. A., and Vetterling, W. T. (1992). "Numerical recipes," 2nd edition. Cambridge University Press, Cambridge.

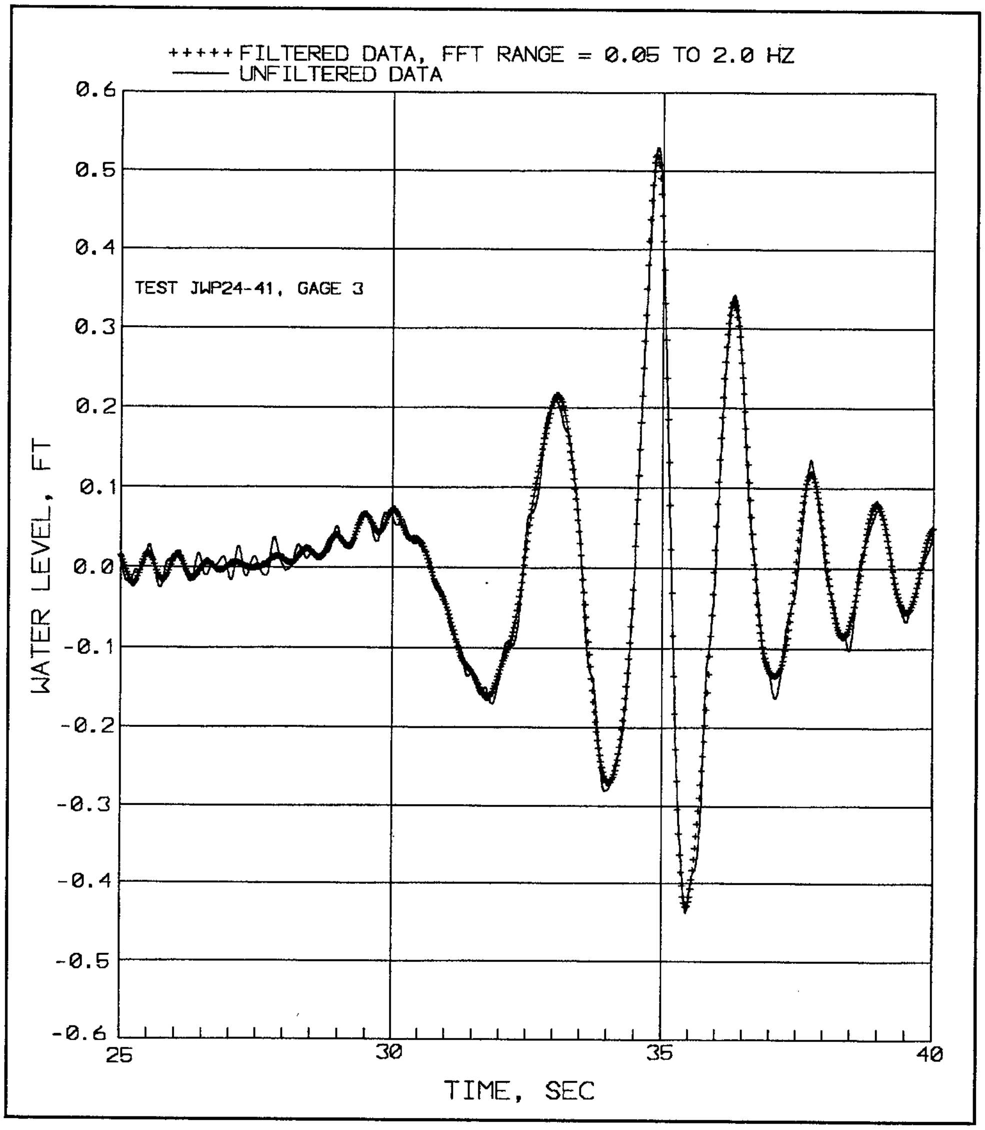

Figure 15. Test JWP24-41, gage 3 with 0.05 to 2.0 Hz filter

of 0.05 to 5.0 Hz. The filtered data closely matches the boat waves and the ambient fluctuations. Similar plots of data from the river showed no impact of the 0.05 to 5.0 Hz FFT filter on the boat waves. The 0.05 to 5.0 Hz filter was used on all data from Johnson Lake and the Kenai River. One question that begs answering is why use a filter at all if the criteria is to have no effect on the boat wave signal. The answer is that electronic data can have noise and spikes that are high frequency events. The computer programs used in this study searched the water level data for the maximum wave height defined as maximum trough to following crest. If spikes or noise were present in the record, the programs would have to be coded to distinguish between a spike and the boat wave. While this could likely be done, it was easier to use the 5-Hz FFT filter to remove spikes and prevent the programs from finding erroneous maximum wave heights. It should be noted that in all the time-histories plotted, no spikes were observed, but with more than 800 tests with four channels per test, the filter provided insurance against not plotting all 3,200 time-histories.

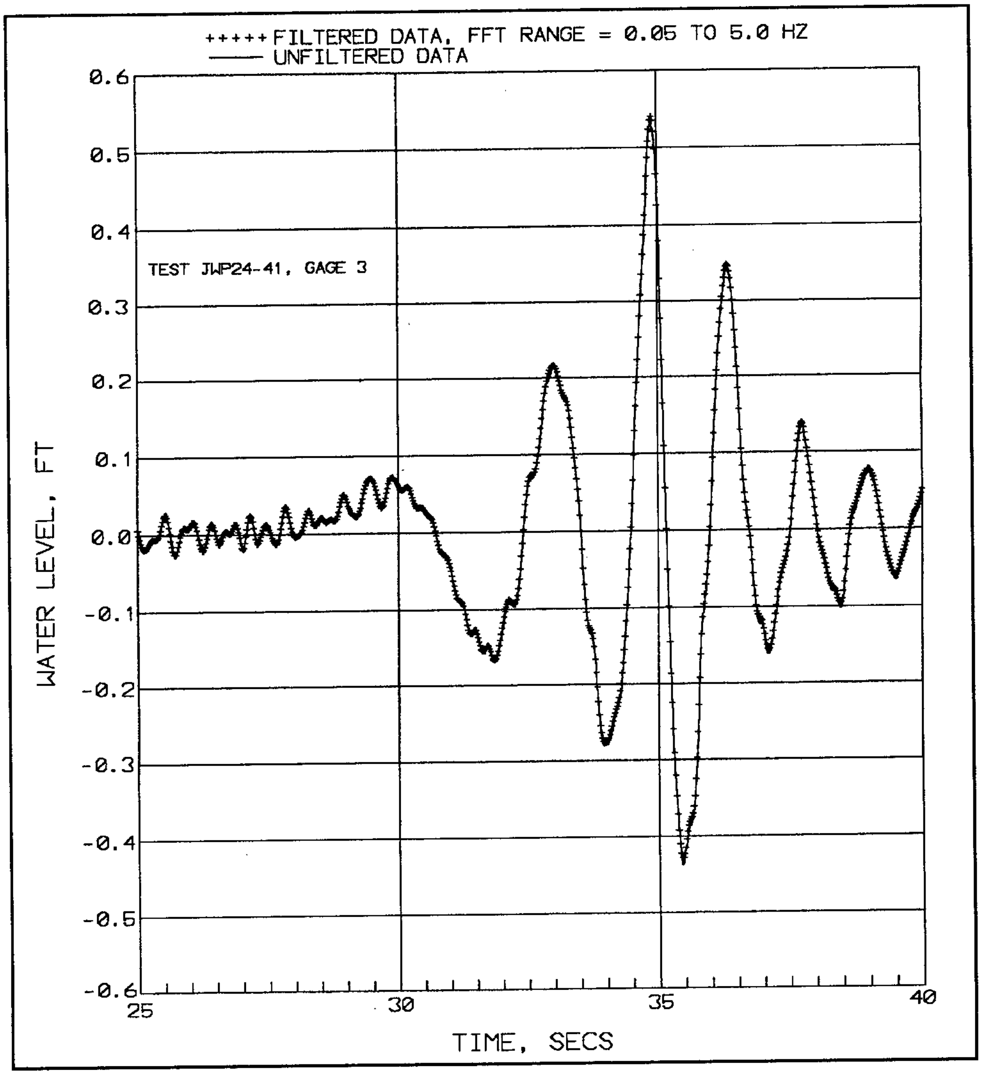

Figure 16. Test JWP24-41, gage 3, with 0.05 to 5.0-Hz filter

Time-histories

The time-history of water level (Figures 2, 15, and 16) is a trace of the water level during the passage of a boat. The time-history is developed by first measuring the continuous signal of voltage from the wave gages. The continuous voltage signal is converted into digital data at a rate of 50 samples of voltage per sec. The previously presented calibration curves are used to convert the 50 samples/sec voltage data to water level data in units of feet of water. The FFT filter is used to remove any extraneous data having frequencies of less than 0.05 Hz or greater than 5 Hz. The plot of the water level in feet versus time is called the time-history. The time-history is used to determine all needed wave characteristics such as height, period, wavelength, wave angle, and wave energy.

Test Conditions and Data

Five tests were run for each condition at Johnson Lake and eight tests for each condition at Kenai River. Test conditions and maximum wave height and period of the maximum wave for the five boats on Johnson Lake and two boats on the Kenai River are shown in Tables 3 to 15. One of the five tests at Johnson Lake and one of the eight tests at Kenai River was selected as representative of the five or eight tests (designated by "plot" in the first column of Tables 3-15). These representative tests were used in wave energy and wave angle calculations.

The maximum wave is determined as the wave having the maximum difference between the trough elevation and the following crest. Trough for each wave is determined as the minimum water level between the down crossing and the following upcrossing of the wave profile through the still-water level. Crest for each wave is similarly the maximum water level between upcrossing and the following downcrossing of the still-water level. The period shown in the data tables is twice the time between the trough and crest of the maximum wave. Also shown are the mean and standard deviations of the five replicates on Johnson Lake and eight replicates on Kenai River. The maximum wave height data are plotted in Plates 8-26. Also shown on Plates 8-26 is a best fit line for each loading based on a power function equation having the form of MAXPOW or MAXWAV= coefficient $(X)^{Power}$, where X is the lateral distance from the boat.

Vessel Froude Number

Froude number based on vessel length is an important parameter defining boat wave characteristics and is shown in Table 16. Gross boat length is used while recognizing that not all the length is in the water and that the length in the water changes with speed. All of the F_L were consistent except the WP35 in Johnson Lake versus the WP35 in Kenai River. Froude numbers for the MAXPOW tests other than WP35 were equal in river and lake and ranged from 1.3 to 1.7. The fact that the F_L for the WP was less than for other boats is not a concern because the WP is a heavier boat. The area of concern is the F_L for the WP35 is less in the lake than in the river. The F_L in lake and river were the same for the WP50, KF35, and KF50. All MAXWAV tests had F_L of about 0.5.

As reported by Stumbo et al. (1999),[1] boats having F_L greater than 1 are dominated by diverging waves with little influence of transverse waves. With the exception of the JWP35, all MAXPOW tests were dominated by the diverging waves based on the large Froude number. The MAXWAV tests all had F_L of about 0.5 where transverse waves are present. For a typical speed in the MAXWAV tests of 8.5 mph, Figure 1 shows that a cusp point will exist at every 12 ft measured perpendicular to the sailing line of the boat. Halfway between these cusp points the diverging and transverse waves will be out of phase and wave heights will be less. It would have been costly in time and dollars to place gages close enough to resolve the cusp points in the MAXWAV tests. This study deals with the effects of these cusp points in the MAXWAV tests by simply recognizing that they are one of the factors that lead to greater variability in the MAXWAV tests.

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[1] Stumbo. op. cit. p. 3.

8 Analysis of Data

Maximum Wave Height

Standard deviation of maximum wave height

The standard deviation (STD) of maximum wave height was determined for each of the five and eight test groups at Johnson Lake and Kenai River as shown in Tables 3-15. The data were broken down into four groups of Johnson Lake MAXPOW, Johnson Lake MAXWAV, Kenai River MAXPOW, and Kenai River MAXWAV because each group had the same tests conducted on each boat in the group. The average standard deviation for each of the four groups was determined for each boat as shown in Table 17. Coefficients of variation (standard deviation/mean) for the four groups were 0.08, 0.09, 0.14, and 0.13. The standard deviations demonstrate the difficulties reported by the boat operator with the motor used on the KL and LW for the MAXWAV tests. The standard deviations from the Analysis of Variance (ANOVA) presented subsequently and average standard deviations in Table 17 show that the four column headings in Table 17 represent four different populations that will be analyzed separately.

Effects of trim on maximum wave height

Trim of the boat was not measured nor was it systematically varied in the tests because trim, unlike motor power, would be difficult to control. The trim used in the tests was the trim resulting from the most typical loading pattern for each boat and the trim of the motor. The trim of the motor was maintained at the setting provided by the boat owner. It is possible that, had the tests been conducted with nontypical loadings and thus nontypical trims, the comparisons may have been different. The objective of these tests was to compare typical loadings and thus typical trims for different boats. Future tests should consider measuring the static and underway trim to determine how significant trim is for the small boats used in this study. The similar and slightly greater wave height of the Lowe 40 compared to the Lowe 35 is opposite to the trends of the other 3 boats and may be the result of trim of the boat. Several tests with the Aleckson boat revealed an effect of trim on maximum wave height. Tests JNW28-16 to 28-20 were run with one setting of the trim on the boat. Tests JNW28-31 to 28-35 were run with the same loading, one person and the closest sailing line, but a change in the trim resulted in an increase in boat speed and an increase in wave height.

Analysis of variance (ANOVA) of maximum wave height

ANOVA is used to determine if differences exist amongst the means of MAXPOW or MAXWAV for different conditions. In the ANOVA, MAXPOW or MAXWAV is the dependent variable and load, distance, motor power, and direction of travel (on the river only) are the independent variables. The ANOVA can determine if at least one difference exists between boats or loads or sailing lines or distances, but ANOVA will not define which ones are different. If the ANOVA shows that at least one difference exists, comparison of means techniques are then used to determine which means are different. In this study, Student-Newman-Keuls (SNK) is used to compare means. In the ANOVA that will be presented subsequently, load is classified as light (three passengers), medium (four passengers), or heavy (five passengers for LW and KL; six passengers for WP and KF). Sailing line distance was classified as 1-9 for the MAXPOW tests. At the Johnson Lake MAXPOW tests, lateral distances from the center of the boat are referred to as SAIL or DIST and were 1 = 30 ft, 2 = 46.1 ft, 3 = 61.3 ft, 4 = 79.0 ft, 5 = 95.1 ft, 6 = 110.3 ft, 7 = 117.0 ft, 8 = 133.1 ft, and 9 = 148.3 ft. At the Kenai River MAXPOW tests SAIL or DIST were 1 = 32 or 33.3 ft, 2 = 40.4 ft, 3 = 49.4 ft, 4 = 80.0 or 81.3 ft, 5 = 88.4 ft, 6 = 97.4 ft, 7 = 125.0 or 126.3 ft, 8 = 133.4 ft, and 9 = 142.4 ft. Note that for the Kenai River, gages 3 and 4 were not parallel to the sailing lines (as at Johnson Lake), thus the two different distances (32 and 33.3 ft) for SAIL or DIST = 1. At the Johnson Lake MAXWAV tests, SAIL or DIST were 4-9 and were selected because initial MAXPOW tests showed more consistent results at the two farthest sailing lines. All nine distances were not run to reduce the total number of tests. At the Kenai River MAXWAV tests, DIST were 1-6. DIST 1-6 were used at Kenai River rather than 4-9 as at Johnson Lake because the farthest sailing line at Kenai River showed inconsistent results. For the MAXPOW tests, low power was 35 hp for all boats and high power was 50 hp for WP and KF and 40 hp for KL and LW. For the Kenai River tests, direction or Direct was upstream or downstream.

In ANOVA, interactions occur when one treatment, for example power in this study, does not affect the measured data, maximum wave height in this study, in the same way for all cases. If significant, these interactions can result in the ANOVA declaring a difference to exist when it does not exist. Without any statistical analysis, one would expect interactions in the data collected in this study. For the same loading, the loads were distributed differently in all four boats and the heaviest loading was five people in the 16-ft boats (KL and LW) and six people in the 20-ft boats (WP and KF). While the motor was the same motor on the Klamath and the Lowe, the motors on the Koeffler and the Willie Predator were different and the propeller on the Koeffler differed from the other three boats which had the same propeller. Interactions between boat and distance are likely the results of the wave angle β being different for some of the boats, particularly the WP, and some of the heavier loadings causing larger waves which are steeper near the boat and have a different decay rate as shown in Plates 8-26. Interactions are dealt with herein by plotting the data to see if the interaction is leading to an erroneous conclusion. The following four sections will present the plots. In addition, SNK will be used to compare means of the various effects.

Johnson Lake MAXPOW tests

The plots of Johnson Lake MAXPOW for different combinations of variables are shown in Figures 17-29. Each point is the average of the five replicates. The following conclusions are based on analysis of the plots:

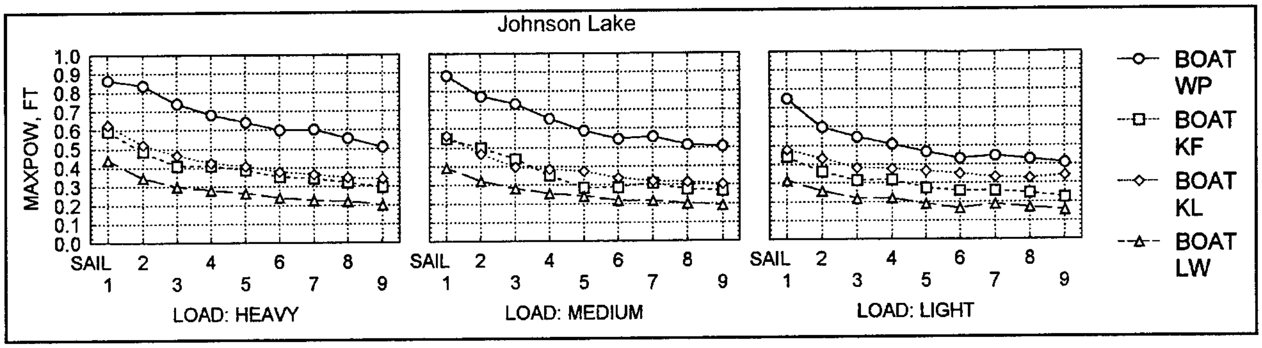


Figure 17. MAXPOW vs. boat vs. distance, low power

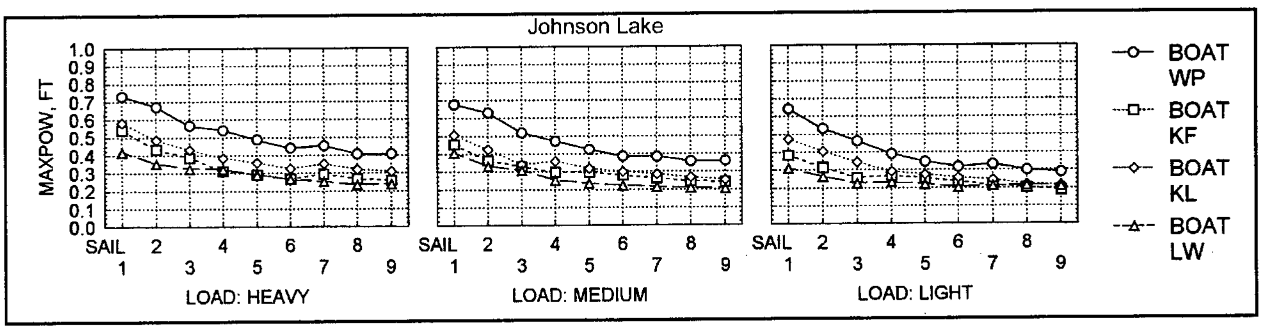


Figure 18. MAXPOW vs. boat vs. distance, high power

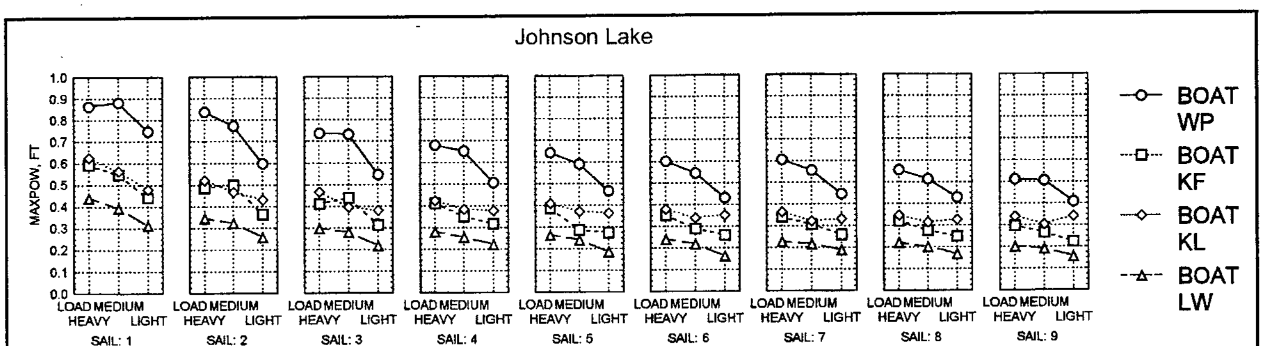


Figure 19. MAXPOW vs. boat vs. load, low power

a. Maximum wave height from the four boats are different (Figures 17-23). The WP is the largest, KF and KL next, and LW the smallest. Differences between boats are largest at the lower power.

b. Maximum wave height decreases with increasing distance from the boat (Figures 17, 18, 24, and 25).

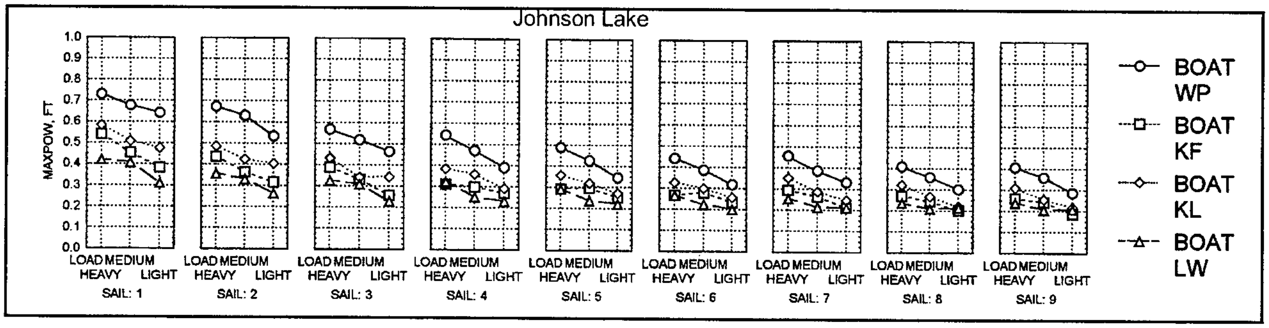


Figure 20. MAXPOW vs. boat vs. load, high power

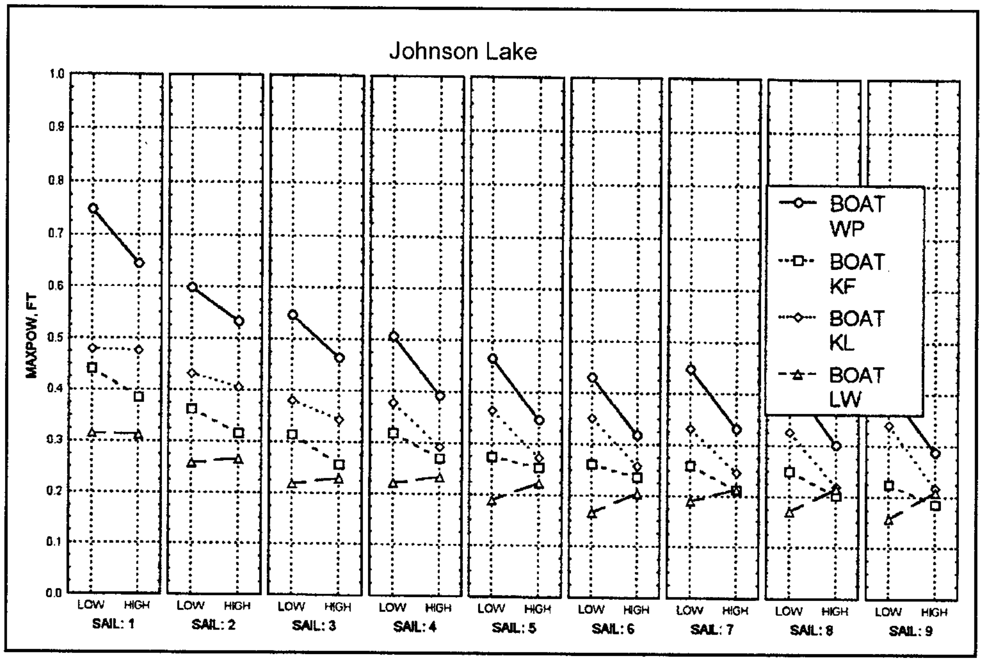


Figure 21. MAXPOW vs. boat vs. power, light load

c. Maximum wave height decreases with decreasing load (Figures 19, 20, 24-29).

d. Maximum wave height decreases with increasing power for the WP, KF, and KL (Figures 26-28). Differences in MAXPOW due to power effects are not significant for the LW (Figure 29).

The Johnson Lake ANOVA is conducted for five sets of variables to eliminate the differences in power (35 versus 40 or 50), loading (three, four, and five people versus three, four, and six people), boat length (16 ft versus 20 ft), and hull form (V-hull versus flat bottomed) and minimize the interactions. The ANOVAs are as follows:

a. Table 18a: WP (20-ft-long V-hull) for all three loads, both powers, and all nine distances to evaluate the differences due to load, power, and distance.

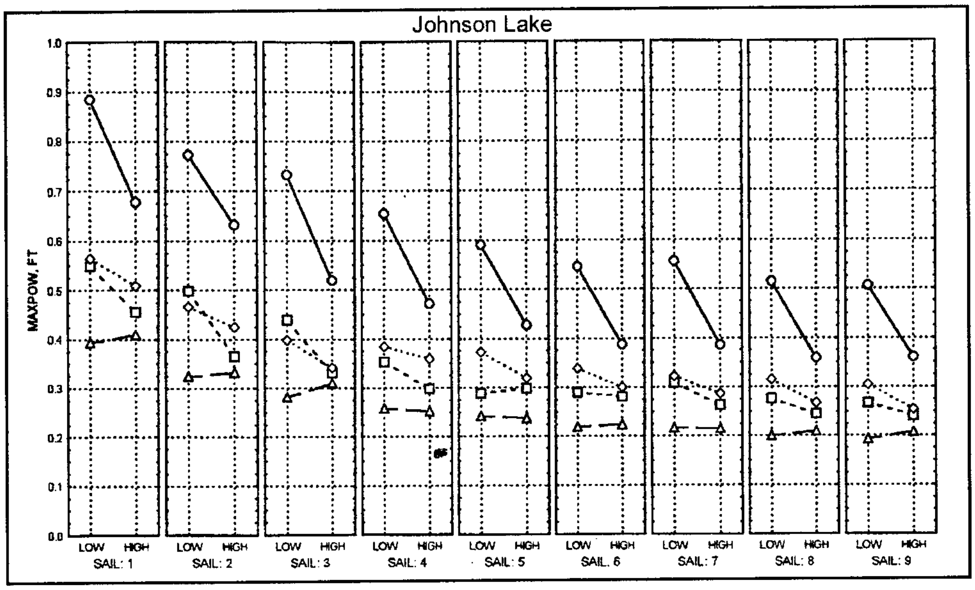


Figure 22. MAXPOW vs. boat vs. power, medium load

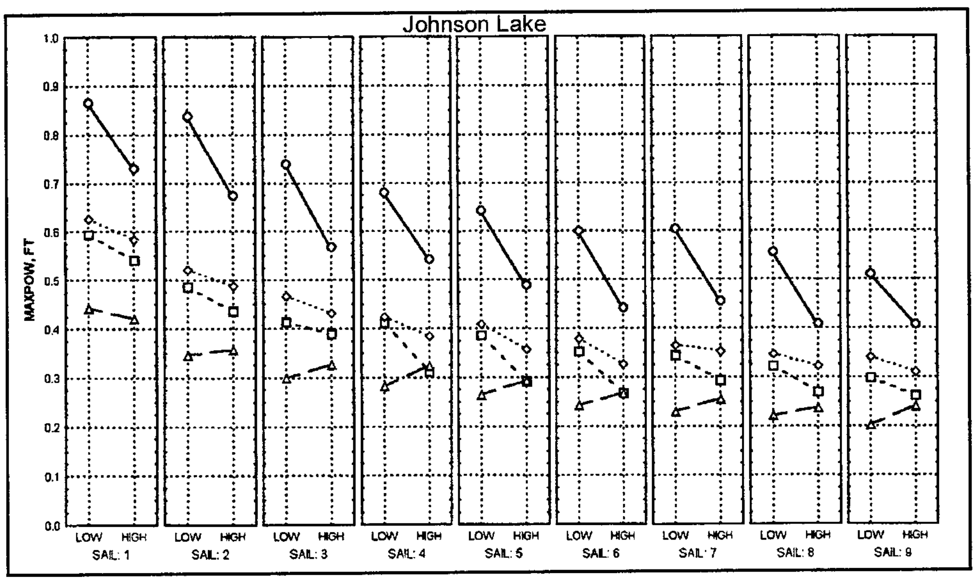


Figure 23. MAXPOW vs. boat vs. power, heavy load

b. Table 18b: KF (20-ft-long flat bottom) for all three loads, both powers, and all nine distances to evaluate the differences due to load, power, and distance.

c. Table 18c: KL (16-ft-long V-hull) for all three loads, both powers, and all nine distances to evaluate the differences due to load, power, and distance.

d. Table 18d: LW (16-ft-long flat bottom) for all three loads, both powers, and all nine distances to evaluate the differences due to load, power, and distance.

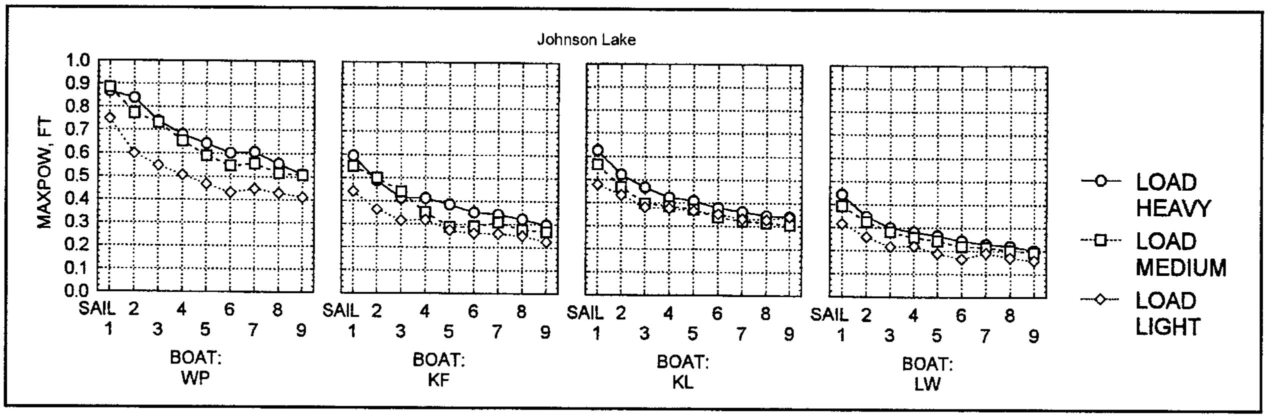


Figure 24. MAXPOW vs. load vs. distance, low power

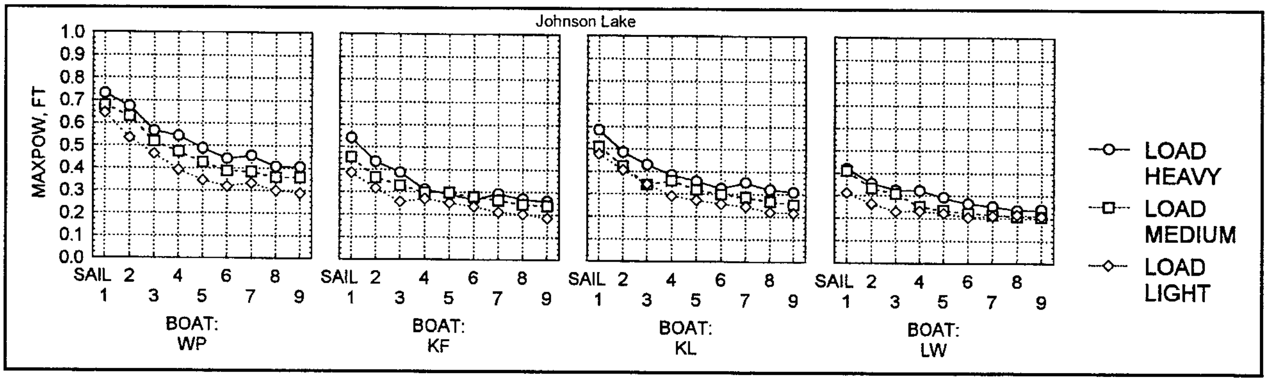


Figure 25. MAXPOW vs. load vs. distance, high power

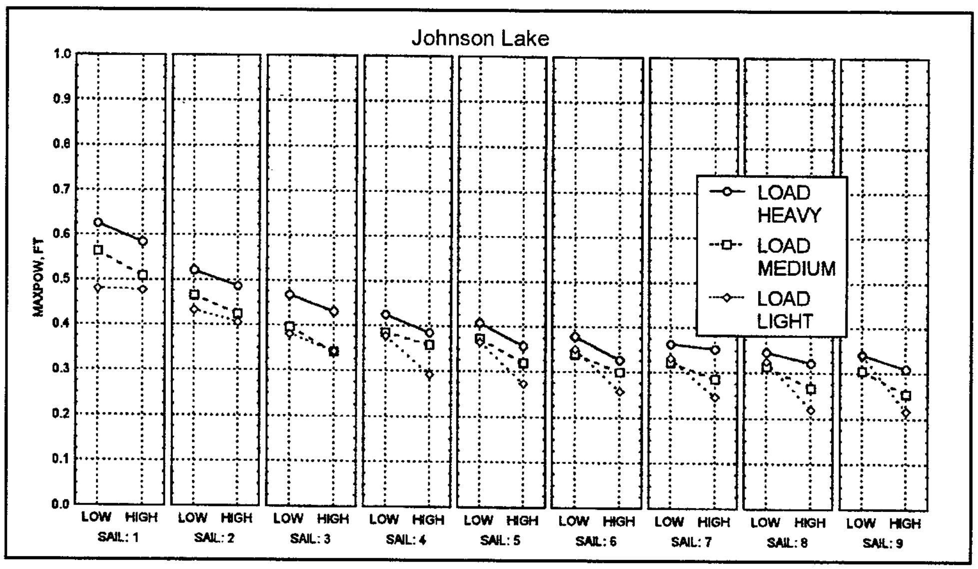


Figure 26. MAXPOW vs. load vs power, Klamath

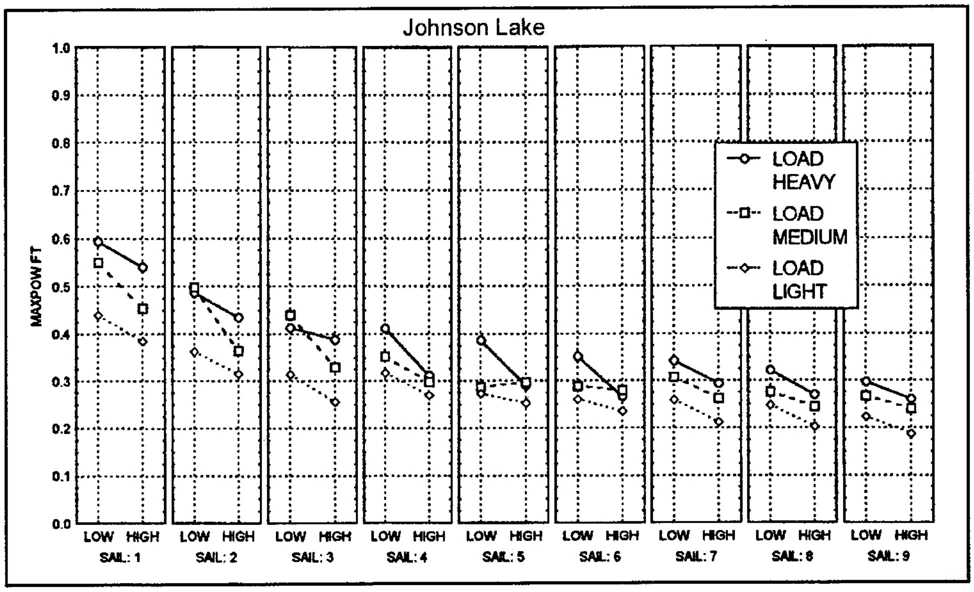


Figure 27. MAXPOW vs. load vs. power, Koeffler

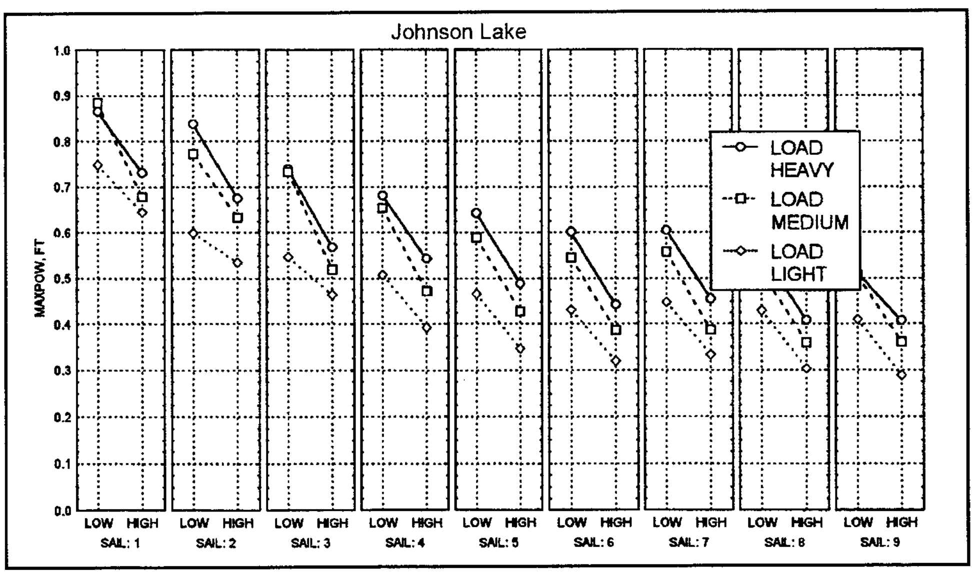


Figure 28. MAXPOW vs. load vs. power, Willie Predator

e. Table 18e: WP, KF, KL, and LW for all nine distances, common loadings of three and four persons, and the common power of 35 hp to evaluate differences in boats.

The ANOVAs for the individual boats in Tables 18a-18d shows that at least one difference exists for the main effects of loading, distance, and power. The ANOVA for all four boats in Table 18e shows that at least one of the boats is different. The ANOVA agrees with the conclusions based on analysis of the plots. Significant interactions ($p<0.05$) exist for many of the effects. Interactions are indicated in Figures 17-29 when the lines from different effects are not parallel, particularly when they cross one another. Many of the interactions result from

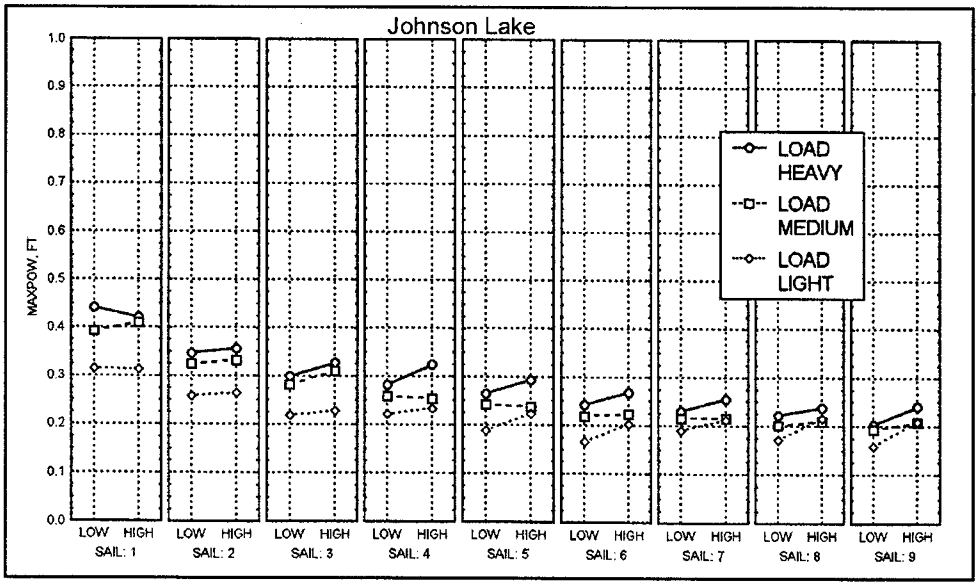


Figure 29. MAXPOW vs. load vs. power, Lowe

small variations in MAXPOW of less than 0.05 ft. Interactions are addressed as follows:

a. All four individual boat ANOVAs (Tables 18a-d) show interaction of load and sail (distance). Figures 19 and 20 show that at all distances, load causes increase in maximum wave height for increasing load. Figures 24 and 25 show that at all loads, wave height decreases with distance. The interactions are negligible and do not invalidate the conclusion that differences occur as a result of both load and distance.

b. The individual boat ANOVAs for the WP, KL, and LW (Tables 18a, c, and d) show interaction of load and power. Figures 26-28 show that at all loads, an increase in power causes a decrease in maximum wave height for the WP, KF, and KL. The figures also show that at both powers, an increase in load causes an increase in maximum wave height. The interactions are negligible and do not invalidate the conclusion that differences occur as a result of both load and power for the WP, KF, and KL. Figure 29 shows the interactions invalidate the ANOVA conclusion of differences due to power for the LW.

c. The individual boat ANOVAs for the KF and LW (Tables 18b and d) show interaction of sail (distance) and power. This interaction may be the result of differences in wave angle for different speeds which occur for the different powers. Figures 21-23 show that at all distances power causes differences in wave height except for the LW. Figures 17 and 18 show that at both powers, maximum wave height decreases with increasing distance. The interactions are negligible and do not invalidate the conclusion that differences occur as a result of sail (distance), except for the LW.

SNK is used to compare means of power for each boat (Table 19a), load for each boat (Table 19b), and boat only (Table 19c). Also shown is the critical range at p=0.05 which is the difference that must exist between adjacent means in a rank ordered list before they are declared significantly different.

The SNK agrees with the ANOVA and the conclusions based on analysis of the plots. Based on the power data in Table 19a, the average change in MAXPOW for the WP and KF going from 35 to 50 hp is a 17 percent decrease. The change from 35 to 40 hp is a 12 percent decrease for the KL. The plots and the SNK show the change from 35 to 40 hp for the LW produces no significant difference.

Based on the loading data in Table 19b, the average reduction in maximum wave height going from the heaviest loading to the lightest loading was 22 percent. The average reduction in maximum wave height going from the heaviest to the medium loading was 10 percent.

Based on the boat data in Table 19c, all boats are different.

Johnson Lake MAXPOW regression equations

Multiple regression was used to develop predictive equations for the MAXPOW tests. The data were broken into V-hull and flat-bottomed boats because the V-hull WP and KL produced larger MAXPOW (Table 19c) than their flat-bottomed counterparts having the same length, the KF and LW. For the 35-hp boats, the V-hull MAXPOW is about 66 percent greater than the flat bottom for the same loadings of three and four people. Motor power to weight (PW) is a commonly used ratio for different types of vehicles and was tested herein for application to the Kenai River boats. Total boat weight rather than passenger weight was used for the weight in the regression analysis. The MAXPOW data were averaged over all nine distances and all five replicates and plotted in Figure 30 against PW. Figure 30 corresponds to the portion of Figure 1c that is to the right of MAXWAV at point A. The plot shows a dependency of wave height on PW and a difference in V-hull versus flat-bottomed as previously determined. The plot also shows an important factor regarding PW. As PW increases, the curves get flatter (approaches horizontal). This means that a change in power from 35 hp to 50 hp will cause a greater reduction in wave height than a comparable change at a larger power. Power in the PW ratio is in ft-lbs/sec which requires multiplying the hp by 550. It should be noted that the two hull types are converging at the higher PW which means that differences in wave height due to hull type become smaller at higher PW.

Multiple regression was conducted using MAXPOW as a function of PW and distance from the boat for the two different hulls. The parameters were transformed using Log 10 to result in a power function which is frequently used to describe hydraulic phenomenon. Some initial regressions were done to confirm that power and weight should be combined into a single parameter rather than kept separate in the regression. The V-hull regression with power and weight separate resulted in the same exponent for power and weight of 0.82. The flat-bottomed regression with power and weight separate resulted in a different

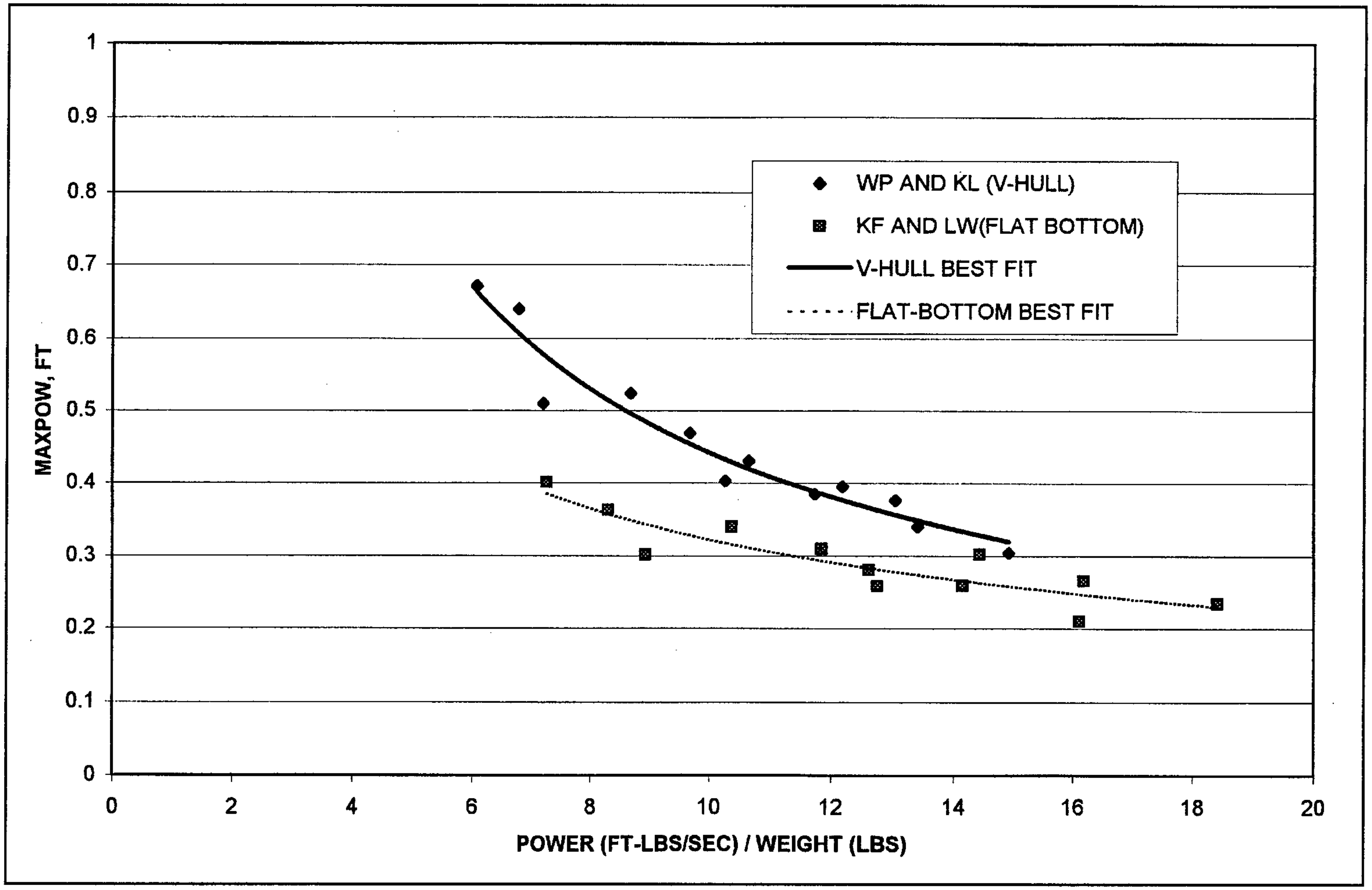


Figure 30. MAXPOW vs. power/weight vs. hull type MAXPOW averaged over all nine distances and all five replicates

exponent for power (0.39) and weight (0.57) but the R^2 was unchanged from the R^2 for the combined regression. Based on the similarity of the exponents for the V-hull and the consistency of the data in Figure 30 using the combined parameter, the combined parameter was used in the regression analysis for both hull types. The equation for the V-hull boats (WP and KL) is

$$MAXPOW(v-hull) = \frac{16.1}{PW^{0.82}x^{0.39}} \tag{7}$$

and has an $R^2 = 0.91$. The MAXPOW from the regression equation is compared to the observed MAXPOW in a scatterplot for the V-hull in Figure 31. Each point in the scatterplot is an actual test data point and does not involve any averaging of the data. The equation for the flat-bottomed boats is

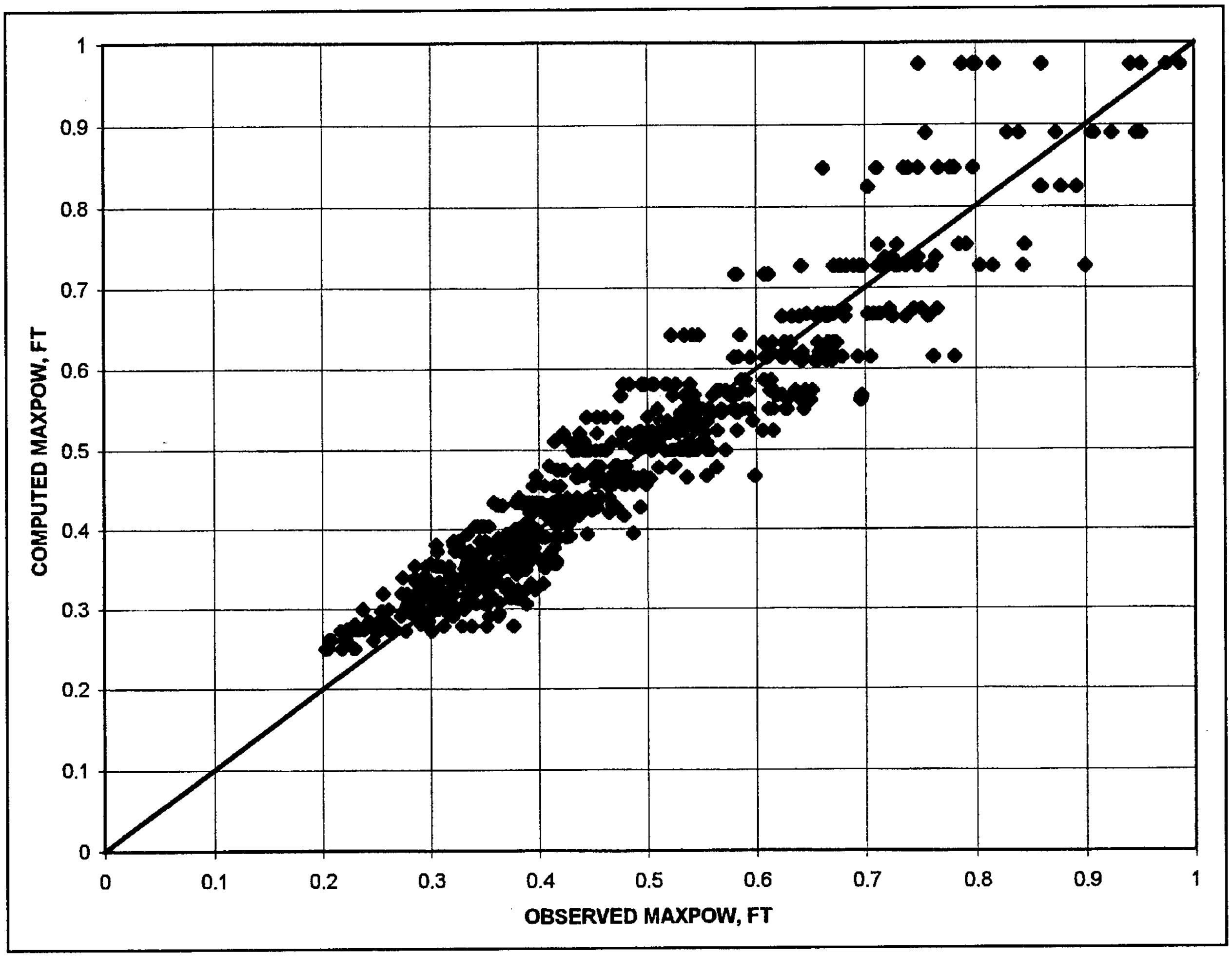


Figure 31. Observed vs. computed MAXPOW, V-hull boats, Johnson Lake, computed MAXPOW = 16.1/(X^0.39*PW^0.82)

$$MAXPOW(flat-bottom) = \frac{6.9}{PW^{0.55}x^{0.41}} \tag{8}$$

and has an $R^2 = 0.83$. The MAXPOW from the regression equation is compared to the observed MAXPOW in a scatterplot for the flat bottom in Figure 32. Each point in the scatterplot is an actual test data point and does not involve any data averaging.

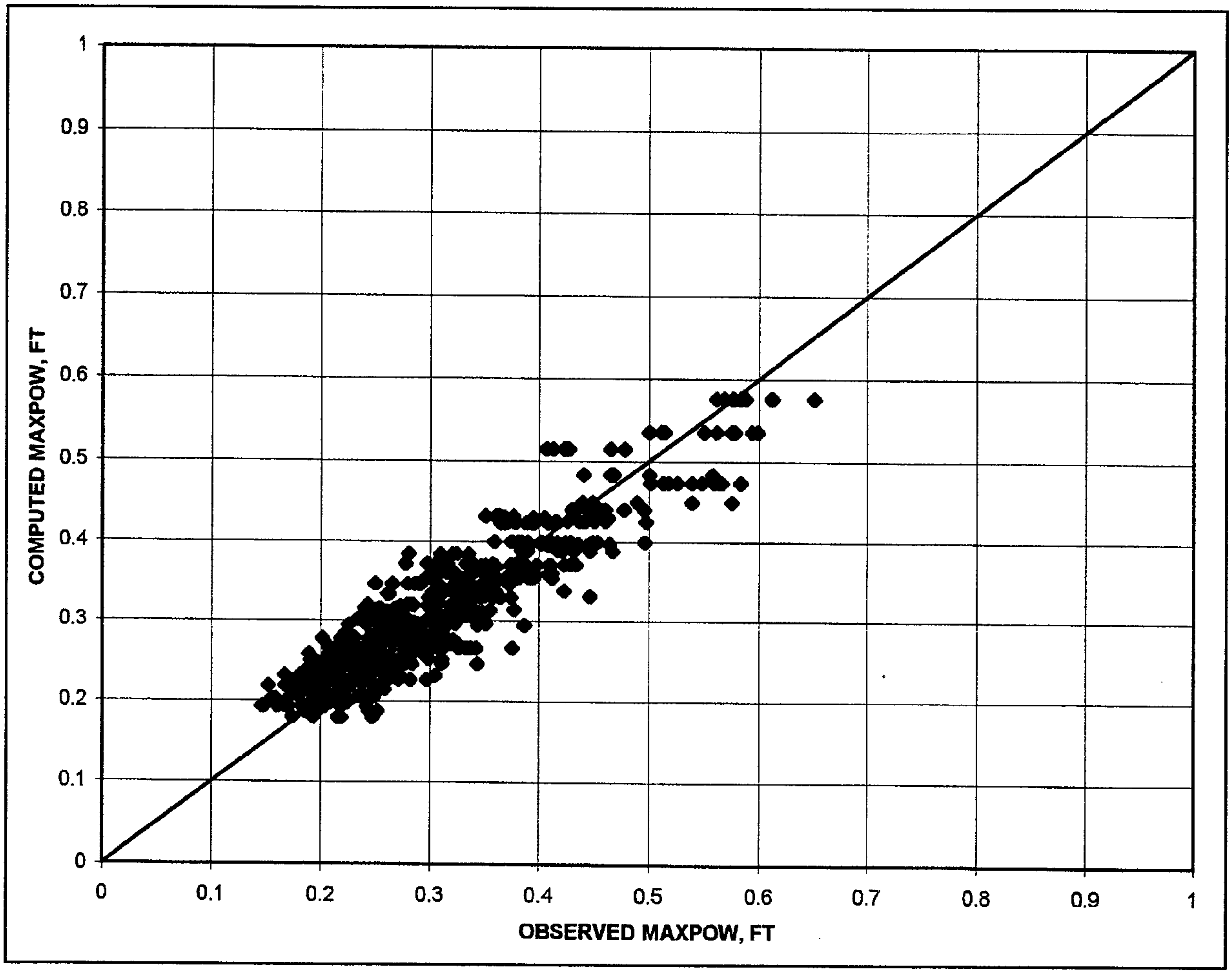


Figure 32. Observed vs. computed MAXPOW, flat-bottom boats, Johnson Lake, computed MAXPOW = 6.92/(X^0.41*PW^0.55)

The regression equations provide an easy way to evaluate different ways to limit MAXPOW and how to compare the different combinations of variables with each other. Figures 33 and 34 present nomographs based on the regression equations. The nomographs correspond to the portion of the curve in Figure 1c that is to the right of MAXWAV at point A. Note that the nomographs cover only the range of PW from the experimental data. As stated previously, another study is needed to determine what wave height and period and frequency of boat passage results in damage to the banks of the Kenai River. Suppose such a study was already conducted and for the wave periods and frequency of passage of the Kenai River boats, the MAXPOW should not exceed 0.4 ft. The equations show that the desired wave height can be achieved in a variety of ways. To reduce wave height, power can be increased, weight decreased, or distance increased.

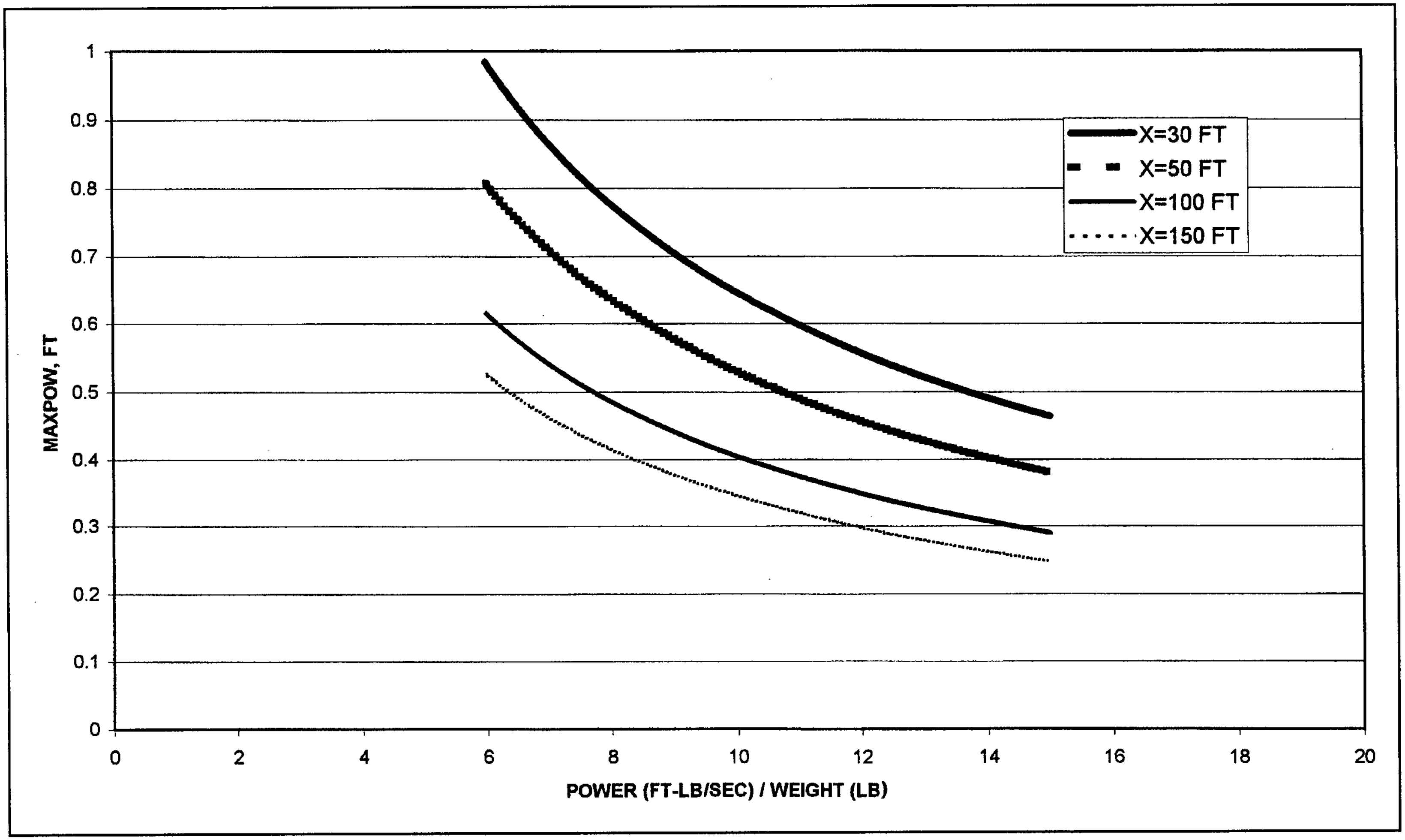


Figure 33. Nomograph for MAXPOW vs. power/weight vs. distance, V-hull boats on Johnson Lake

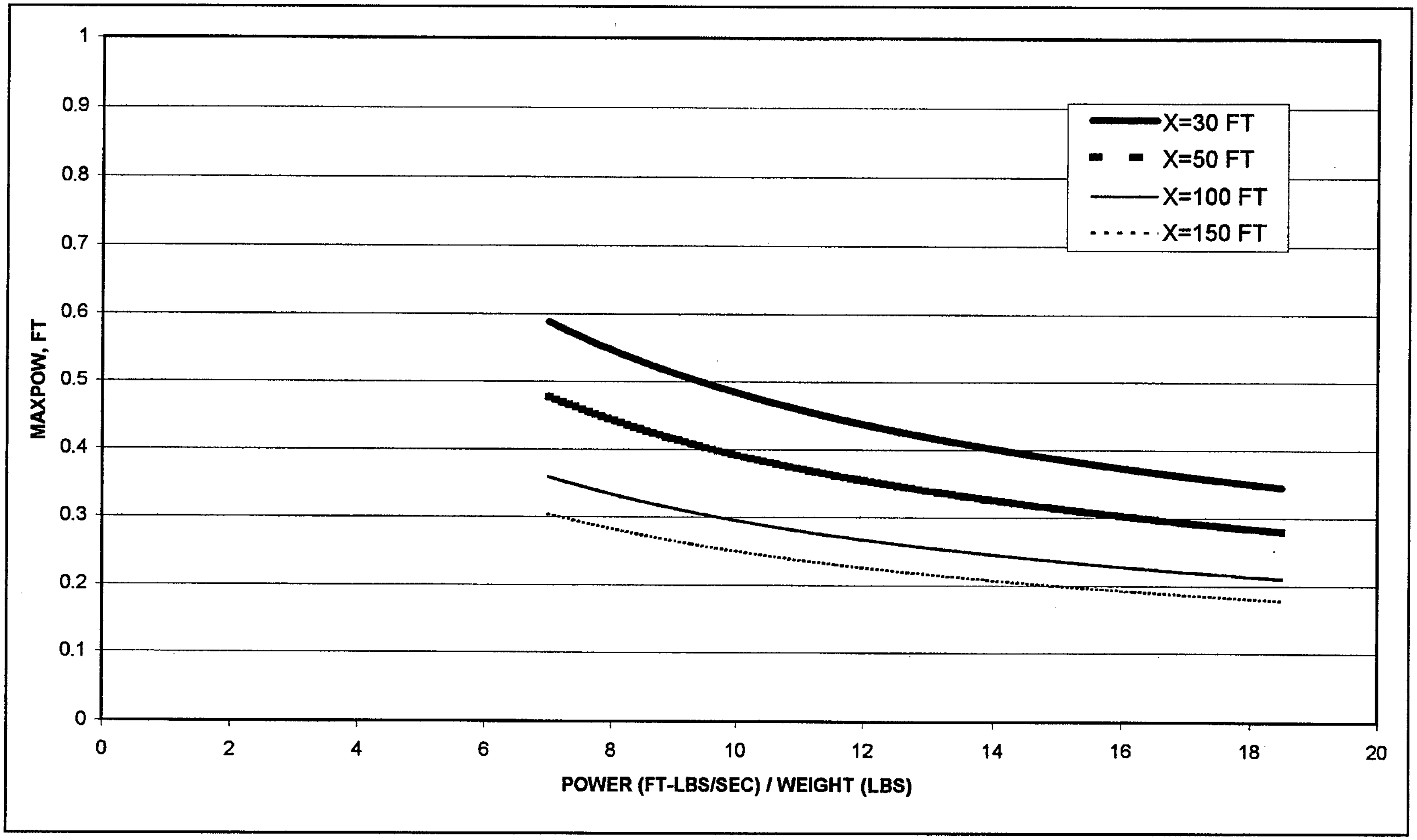


Figure 34. Nomograph for MAXPOW vs. power/weight vs. distance, flat-bottom boats on Johnson Lake

Suppose that safety considerations due to excessive boat speed limit the power to 50 hp. Also suppose that boats are limited to a minimum of 50 ft from the bank. For the V-hull boats, Equation 7 results in a maximum PW of 14.1 which results in a maximum boat weight of 1,950 lb. For the same conditions and a flat-bottomed boat, Equation 8 shows the maximum PW producing a 0.4-ft wave is 9.6 and the maximum boat weight is 2,865 lb. For the same conditions of a 50-hp maximum, the equations are used to determine the wave height for the heaviest boats if boats are kept 150 ft from the bank. The heaviest V-hull boat tested (WP) with six passengers has a weight of 3,170 lb. The PW becomes 50*550/3170= 8.7 and the maximum wave is 0.39 ft. For the flat-bottomed boat, the heaviest boat tested (KF) with six passengers has a weight of 2,650 lb. The PW becomes 50*550/2650= 10.4 and the maximum wave is 0.24 ft.

Johnson Lake MAXWAV Tests

The plots of MAXWAV are shown in Figures 35 and 36 and each point is the average of the five replicates. The following conclusions are based on analysis of the plots:

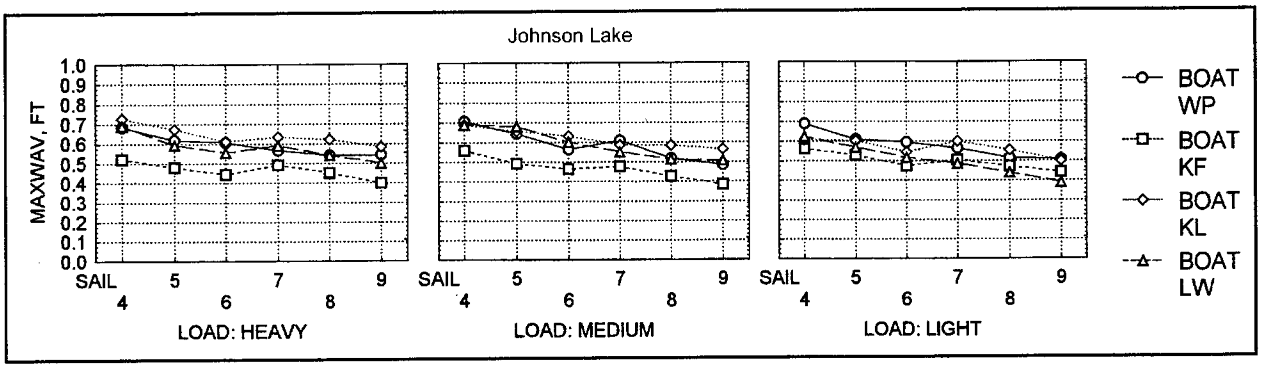


Figure 35. MAXWAV vs. boat vs. distance

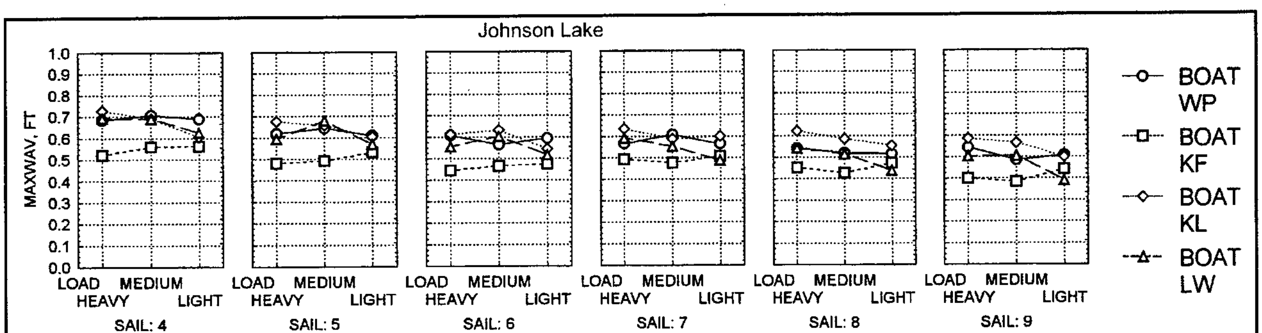


Figure 36. MAXWAV vs. boat vs. load

a. MAXWAV decreases with distance from the boat (Figure 35).

b. There are no differences in MAXWAV due to loading (Figure 36).

c. The KF has a lesser MAXWAV than the other boats. No difference in MAXWAV for the WP, KL, and LW.

The Johnson Lake MAXWAV ANOVA (Table 20) shows that at least one difference exists for all effects of boat, load, and sail distance. The ANOVA agrees with the conclusions based on analysis of the plots except for load. Significant interactions exist for (boat and load) and (boat and distance). Sailing distance (Figure 35) shows a consistent decrease from SAIL = 4 to SAIL = 9 (the only distances used in the Johnson Lake MAXWAV tests) and agrees with the ANOVA. The numerous interactions of load and boat (Figure 36) suggests that no significant differences exist due to load for the MAXWAV tests at Johnson Lake. The ANOVA finding that at least one boat is different is valid based on Figures 35 and 36.

The means of maximum wave height for the Johnson Lake MAXWAV tests averaged over all distances are compared using Student Neuman-Keuls in Table 21.

The SNK in Table 21 shows no differences due to loading of the WP for all three loadings, the KF for heavy and medium loadings, the KL for heavy and medium loadings, and the LW for heavy and medium loadings. Based on Table 21, at least one loading is different which is consistent with the ANOVA. However, considering all loadings and all boats, differences in wave height due to loading are not significant.

Boat effects for Johnson Lake MAXWAV are summarized in Table 22.

The SNK in Table 22 shows no significant difference of the WP and KL. The KF and LW were less than the WP and KL.

Kenai River MAXPOW tests

The plots of MAXPOW are shown in Figures 37-42 and each point represents the average of the eight replicates. The following conclusions are based on analysis of the plots:

a. MAXPOW varies with boat. The WP creates a larger MAXPOW on the Kenai River than does the KF (Figures 37 and 38).

b. MAXPOW varies with distance from the boat (Figures 37-42).

c. MAXPOW is greater for the 35-hp WP than the 50-hp WP. No difference in power is found for the KF (Figures 39 and 40).

d. Direction of boat travel had no significant impact on MAXPOW in the Kenai River (Figures 41 and 42).

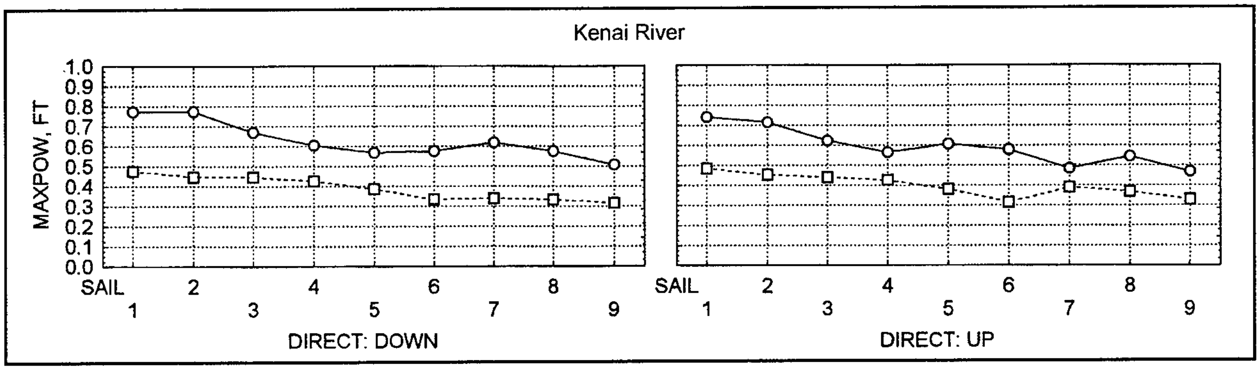


Figure 37. MAXPOW vs. boat vs. distance low power

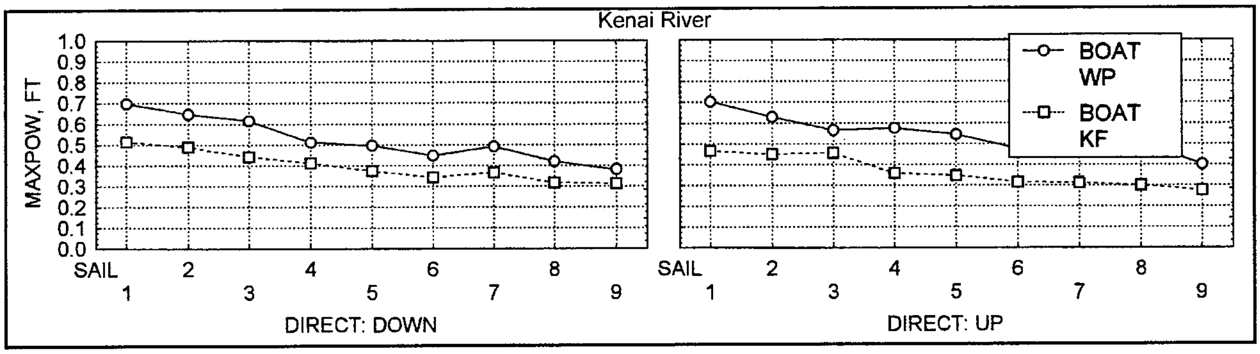


Figure 38. MAXPOW vs. boat vs. distance high power

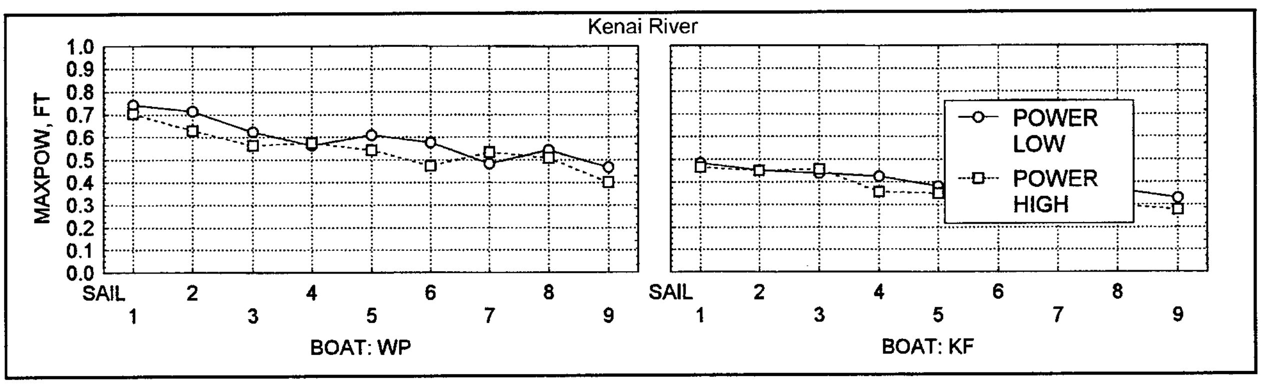


Figure 39. MAXPOW vs. power vs. distance, upstream direction

The Kenai River MAXPOW ANOVA (Table 23) shows that at least one difference exists for the effects of boat, distance, and power. The ANOVA agrees with the analysis of the plots. The ANOVA showed no significant difference of direction. Significant interactions exist between (boat and distance) and (boat and power) but do not invalidate the conclusions that at least one of the boats is different, at least one difference exists because of direction, and that differences exist for at least one power.

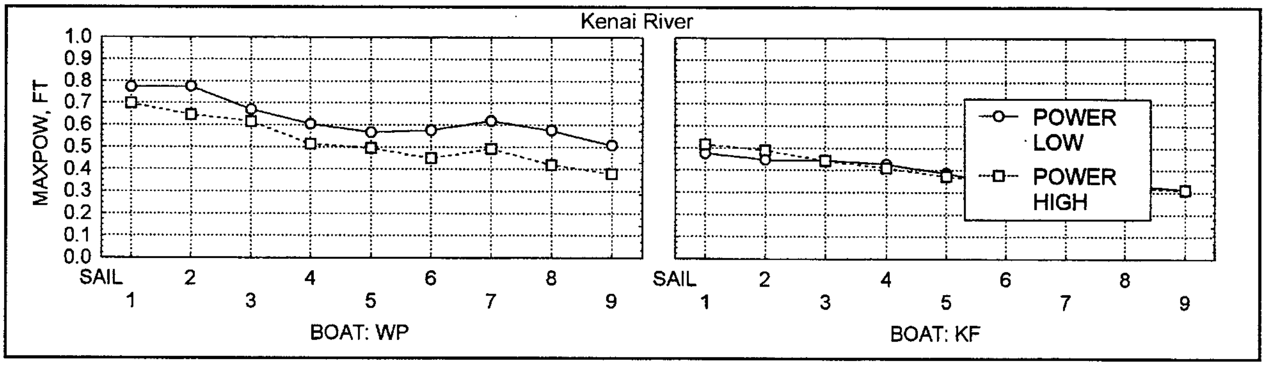


Figure 40. MAXPOW vs. power vs. distance, downstream direction

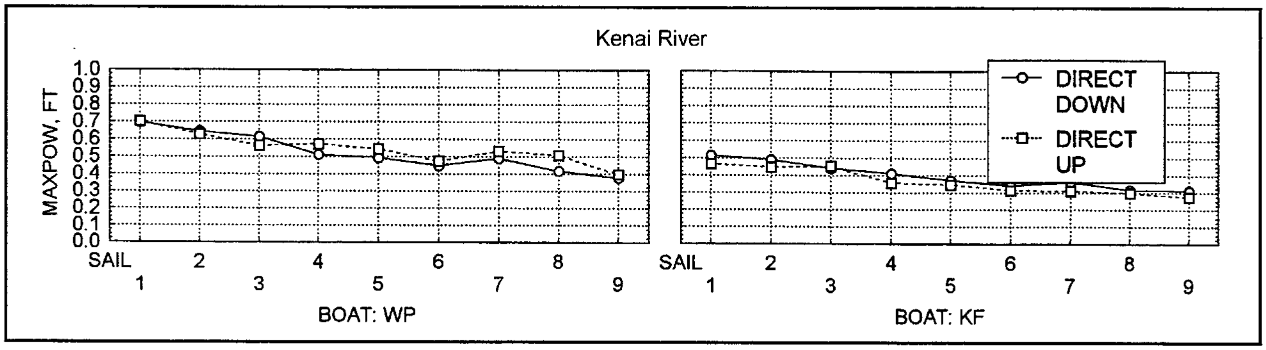


Figure 41. MAXPOW vs. direction vs. distance, high power

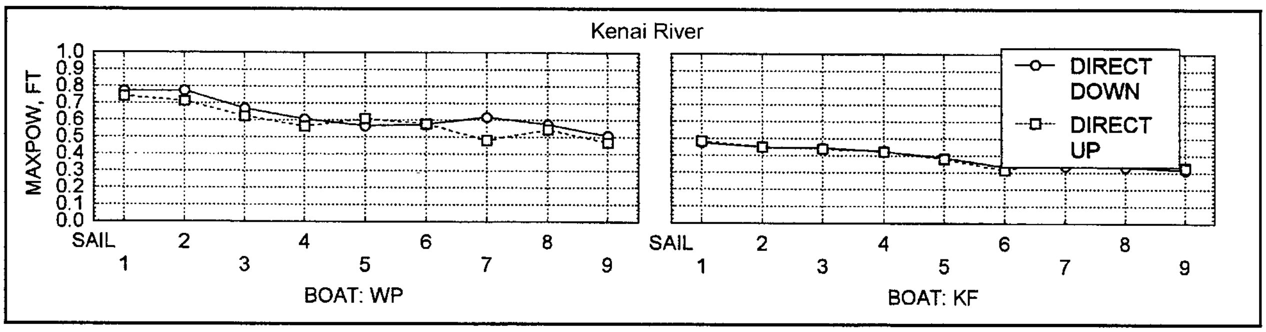


Figure 42. MAXPOW vs. direction vs. distance, low power

The means of Kenai River MAXPOW are compared using SNK in Table 24 and 25.

Boat effects from SNK are shown in Table 26.

The Table 24 SNK agrees with the ANOVA and conclusions from the plots that direction is not significantly different. The Table 25 SNK shows that differences due to power exist for the WP but not for the KF which agrees with the ANOVA and the plots. The WP 50-hp MAXPOW is 12 percent less than the WP 35 hp. From Table 25, the WP 35-hp causes a 55 percent higher ((0.612-0.394)/0.394) wave than the KF 35 hp. The WP 50-hp causes a 39 percent higher

wave than the KF 50 hp. Table 26 shows that for all motors, distances, and directions, the WP produces a 47 percent greater MAXPOW than the KF.

Kenai River MAXPOW regression equations

For the Kenai River MAXPOW tests, only one loading with six people was run. Consequently, power P in ft-lbs/sec (multiply hp by 550) will be used rather than PW in the regression analysis. Because the plots and the ANOVA showed the direction to not be significant in the Kenai River MAXPOW tests, data for both directions will be used in the regression analysis. The equation for the Kenai River Willie Predator MAXPOW for both directions is

$$MAXPOW(WP, Kenai\ River) = \frac{77.6}{P^{0.37}x^{0.28}} \tag{9}$$

and has an $R^2 = 0.55$. The equation shows significant differences due to power and distance which agrees with the ANOVA and analysis of the plots. The equation for the Kenai River Koeffler MAXPOW for both directions is

$$MAXPOW(KF, Kenai\ River) = \frac{3.75}{P^{0.10}x^{0.29}} \tag{10}$$

and has an $R^2 = 0.50$. This equation for both directions shows significant differences due to distance but small exponent of power (0.10) shows only a 3.5 percent change in wave height due to 35 versus 50 hp. This lack of significance of power is in agreement with the SNK. Use of these regression equations and other regression equations in this report should be restricted to the range of data upon which they are based. For example, the WP equations should not be used for powers outside the range of 35-50 hp.

Kenai River MAXWAV tests

The plots for the Kenai River MAXWAV tests are shown in Figures 43-45 and each point is the average of the eight replicates. The following conclusions are based on analysis of the plots:

a. The WP produces a larger MAXWAV than the KF (Figures 43 and 45).

b. Boats moving in an upstream direction create a larger MAXWAV than downstream boats (Figure 44).

c. MAXWAV varies with distance (Figures 44 and 45).

The Kenai River MAXWAV ANOVA (Table 27) shows that differences exist for at least one boat, direction, and distance. Significant interactions exist for (boat and direction), (boat and distance), and (direction and distance).

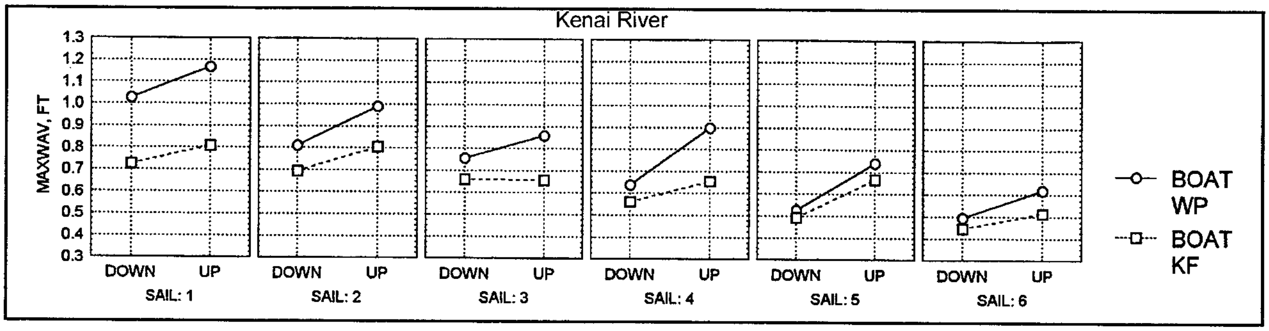


Figure 43. MAXWAV vs. boat vs. direction

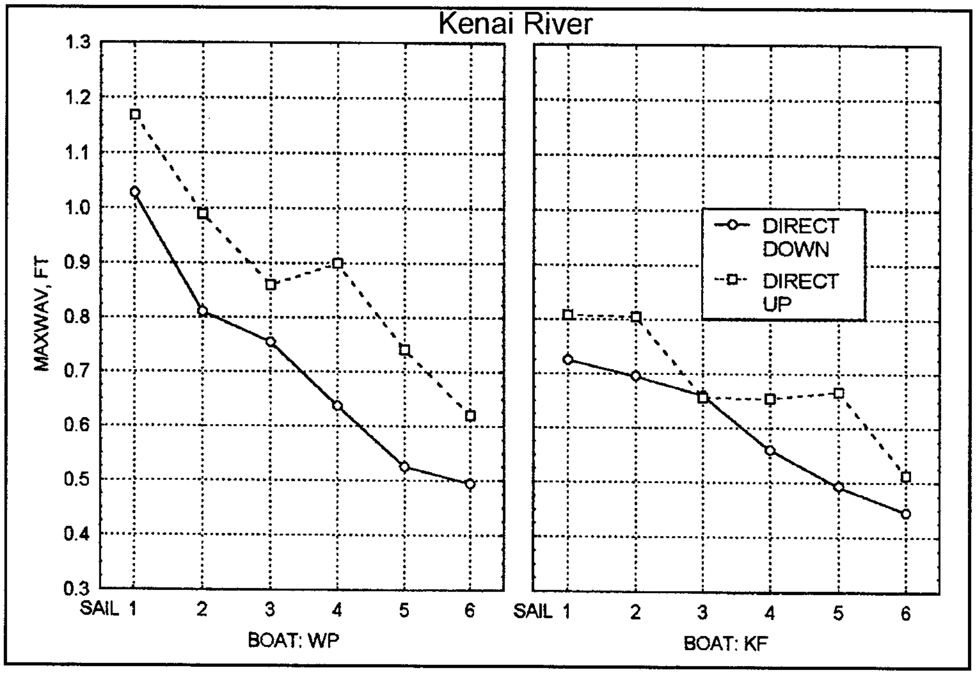


Figure 44. MAXWAV vs. direction vs. distance

The means of the MAXWAV from Kenai River are compared using SNK in Table 28a and 28b.

From Table 28a, the upbound WP MAXWAV at Kenai River is 24 percent greater than the downbound WP MAXWAV ((0.880-0.708)/0.708). The upbound KF MAXWAV at Kenai River is 15 percent greater than the downbound KF MAXWAV. The downbound WP MAXWAV at Kenai River is 18 percent greater than the downbound KF MAXWAV. The upbound WP MAXWAV at Kenai River is 27 percent greater than the upbound KF MAXWAV. Table 28b shows that over all distances and directions, the WP MAXWAV at Kenai River was 22 percent greater than the KF MAXWAV.

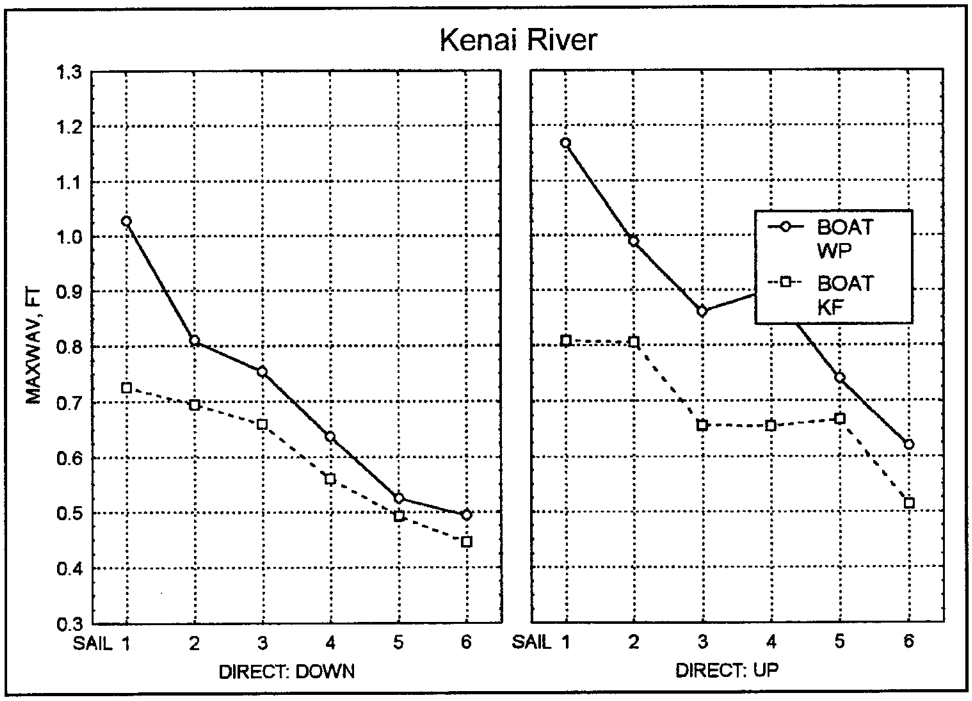


Figure 45. MAXWAV vs. boat vs. distance

Comparison of MAXPOW from flat-bottomed versus V-hulled boats

The V-hull WP and KL produced larger MAXPOW (Table 19c) than their flat-bottomed counterparts having the same length, the KF and LW. While it cannot be ruled out that other factors, such as loading pattern, caused some of the differences in wave height, hull type is the most apparent difference. For the 35-hp boats on Johnson Lake, the V-hull MAXPOW averages 66 percent greater than the flat bottom for equal loadings of three and four people (unequal total boat weight). At the Kenai River, the V-hull WP averages 55 percent greater MAXPOW than the flat-bottomed KF over all distances and the 35-hp motor for the single six-person loading used in the tests. Part of the reason for the greater MAXPOW is that the V-hull boats are about 20 percent heavier than the flat-bottomed boats. The two boat hulls were compared using equal total boat weights. The WP with three loads weighed 2,675 lb and produced an average MAXPOW of 0.524 ft with the 35-hp motor when averaged over all distances. The KF with six loads weighed 2,650 lb and produced an average MAXPOW of 0.413 ft with the 35-hp motor when averaged over all distances. The KL with three loads weighed 1,475 lb and produced an average MAXPOW of 0.381 ft with the 35-hp motor when averaged over all distances. The LW with five loads weighed 1,525 lb and produced an average MAXPOW of 0.291 ft with the 35-hp motor when averaged over all distances. For the 35-hp motor, equal total boat weight, the V-hull produces an average 29 percent greater MAXPOW than the flat bottom. The regression equations plotted in Figures 30, 33, and 34 show that the difference between the two hull types varies with PW when all boats and all loads are considered.

MAXPOW versus speed or applied power

The results presented so far for MAXPOW must be interpreted relative to Figure 1c which presents the general trends between maximum wave height and applied power or speed. As stated previously, each hull shape and weight has its own curve similar to Figure 1c. With a 35-hp motor and a heavy boat like the WP, the location of MAXPOW is just to the right of point A (the MAXWAV). This statement is based on the WP having a MAXWAV that is only 12 percent greater than the WP 35-hp MAXPOW based on similar distances of 4-9 and all loads. With a 35-hp motor and a light boat like the LW, the location of MAXPOW is well to the right of MAXWAV such as at point D. This statement is based on the LW having a MAXWAV that is 166 percent greater than the LW 35-hp MAXPOW. The KF and KL MAXWAV were 60 and 74 percent greater than their corresponding 35-hp MAXPOW. Changes in power (which causes a change in speed) cause changes in position along the curve in Figure 1c. When changing from 35 to 50 hp in a heavy boat like the WP, movement along the curve would be from just to the right of Point A to point B which results in a large reduction in wave height. The WP data presented herein show the largest reduction in wave height from 35 to 50 hp. When changing from 35 to 40 hp in a light boat like the LW, movement along the curve would be from point D to point E which results in little change in MAXPOW. The LW data presented herein show little change in wave height due to motor power. The shape of the Figure 1c curve at large PW may reach horizontal and then begin to exhibit a rise in wave height with speed or applied power. The LW showed a small increase with power but the difference was not significant.

Changes in loading also move the MAXPOW curve, up for increasing load and down for decreasing load. While results presented herein show all changes in load cause changes in wave height, a load change that moves MAXPOW into or away from the region of the hump of wave height can cause a large change in wave height.

Wave Period, Wavelength, and Water Depth Effects

Typical time-histories of water level data are presented in Figure 2 for the Willie Predator, MAXPOW tests, three passengers, and distances of 30.0, 95.1, and 148.3 ft from the boat. Also shown is the half period of the waves throughout the event. Note the decrease in wave period throughout the event and the increasing number of waves at the larger distances as the waves disperse. The change in period throughout the event is why this study defines wave period as the period of the maximum wave. The three time-histories in Figure 2 are from three different boat passages and the times are not related from one figure to the next.

Average wave periods for the maximum wave are shown in Table 29.

The results for the period of the maximum wave are summarized as shown in Table 30. Based on these wave periods and wave theory, the computed wavelengths (L_w) are shown in Table 30 along with the depth/wavelength (d/L_w)

at gages 1 and 3. Deepwater wave conditions exist for all d/L_w greater than 0.5 which means water depth has little influence on wave characteristics. Even at $d/L_w = 0.36$, computed wave speed and length change by only 2 percent from deepwater conditions. The group K-MAXWAV-US is in the range called transitional having d/L_w from ½ to 1/25. Gage 1 at K-MAXPOW-US is also transitional but computed wave speed and length at $d/L_w = 0.28$ change by only 5 percent from deepwater conditions. All other tests can be assumed to have little impact of water depth on wave character. It should be noted that these ranges for depth effects are developed for still-water conditions as in Johnson Lake.

Wave Energy

The damage of wave impact to a streambank depends on many factors including the energy exerted on the bank upon impact. The total energy in the wave train was calculated by summing the energy from each individual wave in the wave train. The wave energy was calculated for the representative tests selected for each group of five and eight tests from Johnson Lake and Kenai River, are shown in Tables 31 and 32. Results for energy at Johnson Lake and Kenai River are summarized in Tables 33 and 34 which present the average wave train energy for all sailing lines and all distances for all boat, motor, and wave type combination along with the energy for six passengers at Johnson Lake to compare to the Kenai River tests. Energy versus boat versus load versus power are plotted in Figure 46 for the Johnson Lake tests. The ending time of the boat wave event for energy calculations was selected in the Kenai River to eliminate reflected waves from the shoreline. The equations used in the energy calculations are applicable to the Johnson Lake environment where ambient velocities are negligible and deepwater conditions exist at all gages. Energy calculations at Kenai River should only be used for relative comparisons because of the large ambient velocities and the effects of shallow depth in the river resulting in the waves falling in the transitional water category. These limitations are particularly important when comparing the upstream MAXWAV and MAXPOW tests to other tests. Wave current interactions have received considerable attention in coastal applications where the direction of the waves is either in the same or opposite direction as the currents. At Kenai River, the direction of the boat waves is about perpendicular to the currents. This condition is far less prevalent and has received less attention in the literature.

The energy calculations at Johnson Lake (Table 33 and Figure 46) show that for the MAXPOW tests for all loads, distances, and motors, the WP produces the greatest wave energy averaging 106 ft-lbs/ft, the KF and KL next with about equal energy of about 52 ft-lbs/ft, and the LW with the least energy of 32 ft-lbs/ft. The 50-hp Aleckson had the same energy as the 50-hp KF. The MAXWAV energy (Table 33) averaged more than twice as large as the MAXPOW energy for all boats and both powers except the WP35 indicating that the WP35 is operating at close to MAXWAV conditions when operating at full power. Under MAXWAV conditions, the WP was about 70 percent greater than the other three boats which had about the same energy (Table 33).

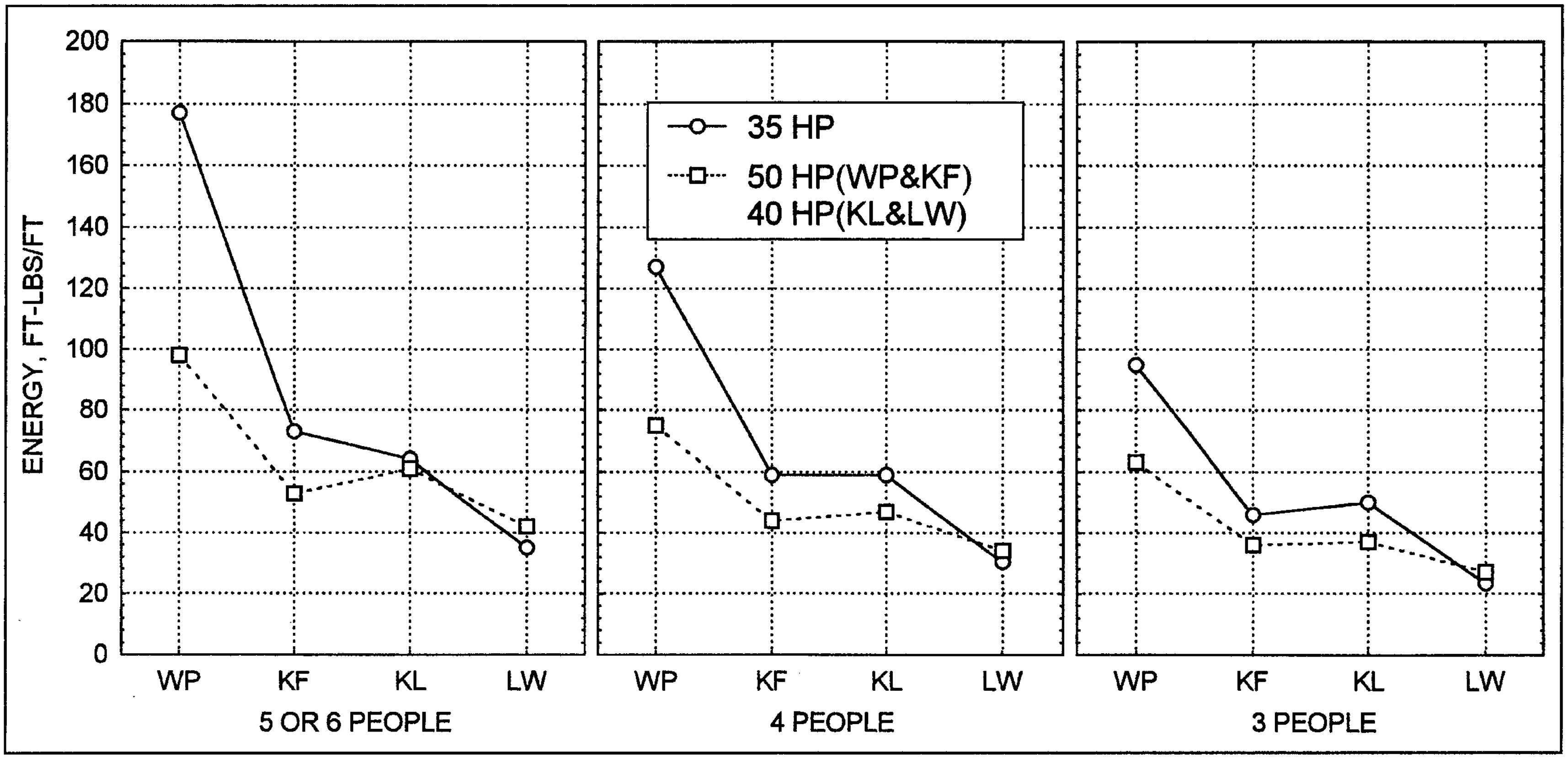


Figure 46. Energy vs. boat vs. load vs. power, Johnson Lake, MAXPOW tests, average over all distances, (for heaviest loading, six people in WP and KF, five people in KL and LW)

At Kenai River, for the MAXPOW tests the WP produced about 60 percent greater energy than the KF (Table 34). Upbound boats produced greater wave energy than downbound. This is a result of the wave period being greater for the upbound boats because MAXPOW for upbound and downbound boats was shown to be equal. In the MAXWAV tests, the WP was greater than the KF. The US MAXWAV tests (Table 34) show values whose magnitudes should be viewed with caution because of the limitations of the theory used to determine wave energy being applicable to zero ambient velocity and deep depths whereas the Kenai River has large ambient velocity and shallow depths. However, even though the magnitudes may be only approximate, the energy in waves having periods of 3.5 sec are going to be significantly greater than waves from the Kenai River MAXPOW tests and the Kenai River downbound MAXWAV tests having periods from 1.34 to 1.93 sec (see Table 30).

Wave Angle

Wave angle was determined using the difference in arrival times at the wave gages. While other parameters like wave height, period, and energy were determined at each gage, multiple gages were needed to determine wave angle, and results are presented on a per sailing line basis. Consequently there are three angles calculated for each boat/motor/loading combination. As can be seen in Figure 2, the wave period varies throughout the event. Also to be noted in Figure 2 is the dispersion of the group of waves with distance.

At Johnson Lake, the approach used herein is to use the arrival time between gages 2, 3, and 4 to solve for the wave angle. Gages 3 and 4 were the same distance from the point of origin of the waves, and it was easy to determine the difference in arrival time because the wave profiles were extremely similar in the lake. The difference in arrival time between gages 2 and 3 was much more difficult to determine because the wave profile dispersed between gages 2 and 3. Gage 3 would have a smaller number of larger waves when compared to gage 2. The approach used herein was to compute the total energy throughout the wave event for gages 2 and 3 by summing the energy from each wave. Next, a curve of energy versus time was developed from the energy of the individual waves for gages 2 and 3. Next, the curve of energy versus time was used to determine the time at which the energy equaled one-half of the total energy from the entire event. This value was selected to represent the centroid of the energy-time relationship and used to characterize the arrival time of the wave train. For Johnson Lake, the difference of this time for gages 2 and 3 was used with the difference between gages 3 and 4 in the equation for Johnson Lake given as

$$\beta = \arctan\left(\frac{\Delta t(3-4)}{\Delta t(3-2)}\frac{\Delta(3-2)}{\Delta(3-4)}\right) \tag{11}$$

Where β is the wave angle relative to the sailing line of the boat shown in Figure 1, Δt (3-2) is the difference arrival time of the wave at gages 3 and 2, and $\Delta(3\text{-}2)$ is the distance from gage 3 to 2 (see Figure 10). At Kenai River, gages 1, 3, and 4 were used to provide a larger time interval than that resulting from the

7.17-ft spacing between gages 2 and 3. Gages 3 and 4 were not parallel to the sailing lines and gages 1, 3, and 4 were not in a right triangle as at Johnson Lake. The resulting equation for the angle relative to a line between gages 3 and 4 on the Kenai River for downbound boats is

$$\beta' = \arcsin\left(\frac{\Delta t(3-4)}{\Delta t(3-1)}\frac{\Delta(3-1)}{\Delta(3-4)}\sin(82-\beta')\right) \tag{12}$$

The angle relative to the sailing line of the boat as shown in Figure 1 is

$$\beta = \beta' + 5 \tag{13}$$

and for upbound boats as

$$\beta' = \arcsin\left(\frac{\Delta t(3-4)}{\Delta t(3-1)}\frac{\Delta(3-1)}{\Delta(3-4)}\sin(98-\beta')\right)$$

The angle relative to the sailing line of the boat as shown in Figure 1 is

$$\beta = \beta' - 5$$

The wave angle was calculated for the representative tests selected for each group of five and eight tests from Johnson Lake and Kenai River are shown in Tables 31 and 32. Results for angle for Johnson Lake and Kenai River are summarized in Tables 33 and 34.

At Johnson Lake, the L-shaped gage array provided satisfactory resolution of wave angles. The MAXPOW tests had angles of 5-6 deg except for the JWP35 and the Aleckson. For the MAXWAV tests, all four boats averaged 16 deg for all loadings.

At Kenai River, the large ambient velocities made it difficult to determine which gage 3 wave was the same wave at gage 4 and the time represented by the centroid calculations of energy were variable. At sailing lines 2 and 3, the angle could not be determined and was marked "unc" in Table 32 for all MAXPOW tests. The downbound MAXPOW tests had an average angle of 10 deg based on sailing line 1. The upbound MAXPOW tests had an average angle of 4 deg. The downbound MAXWAV tests had an average angle of 26 deg and the upbound MAXWAV tests averaged 11 deg.

The effects of wave angle are often described using the cosine of the angle β which is used to reduce the energy of the wave striking the bank for waves that are not perpendicular to the bank. The downbound MAXWAV tests having an average β of 26 deg have a cos $\beta = 0.9$. Had this angle been off by $\pm$ 5 deg, β would have been 0.86 or 0.93. The upbound MAXWAV tests have an average β of 11 deg and cos $\beta = 0.98$. Had this angle been off by $\pm$5 degrees, β would have been 0.96 or 0.99. These values of cosine show that reduction in wave effects due to angle will be small and that the resolution needed in wave angle determination is not large.

Application of Johnson Lake Results on the Kenai River

One question that must be answered is "What results from Johnson Lake can be applied to the Kenai River?" Wave and current interactions can have a significant effect on wave characteristics. MAXPOW data at Johnson Lake and Kenai River for the WP and KF for six loads as shown in Table 35 can be used to compare the two locations.

At Johnson Lake, the Table 35 data show the WP averaged 64 percent higher MAXPOW than the KF when averaged over both powers. At Kenai River, the WP averaged 47 percent higher MAXPOW than the KF when averaged over both powers. While these percentages are not identical, they show that the relative comparisons of boats determined on the lake apply to the river. Specifically, the WP produces the highest MAXPOW, KF and KL next, and the LW produces the lowest MAXPOW which applies to both the lake and river.

Concerning the effects of power on MAXPOW, the Table 35 data show the WP and KF had 19 percent and 18 percent greater wave height for 35 hp compared to 50 hp at Johnson Lake. At Kenai River, the WP had 14 percent greater wave height for 35 hp compared to 50 hp but the KF had no significant difference. For both boats, the effects of the power increase were less on the river than on the lake.

Since only one loading was run on the Kenai River, it is not possible to compare loading effect on MAXPOW and the best available data is that from the Johnson Lake.

Concerning the effects of distance on MAXPOW, the lake MAXPOW decays at a different rate than in the river. This effect on decay rate must be a result of the wave current interaction. Figure 47 shows a comparison of the two different decay rates. The figure uses a hypothetical boat having the same MAXPOW averaged over all distances which is what was observed in comparing lake and river in Table 35.

Wave period of MAXPOW is similar for Johnson Lake and Kenai River downstream boats but differs for the upstream boats.

As shown in the wave angle calculations, the wave angle for MAXPOW was about 6 deg at Johnson Lake and 7 deg at Kenai River. The crest line of the MAXPOW waves were at a small angle to the current direction. The average wave angle for MAXWAV was 16 deg at Johnson Lake and 26 deg for the downbound boats at Kenai River and 11 degrees for the upbound boats at Kenai River. The crest line for the MAXWAV waves was at a larger angle to the current direction, particularly for the downbound boats. The larger angle relative

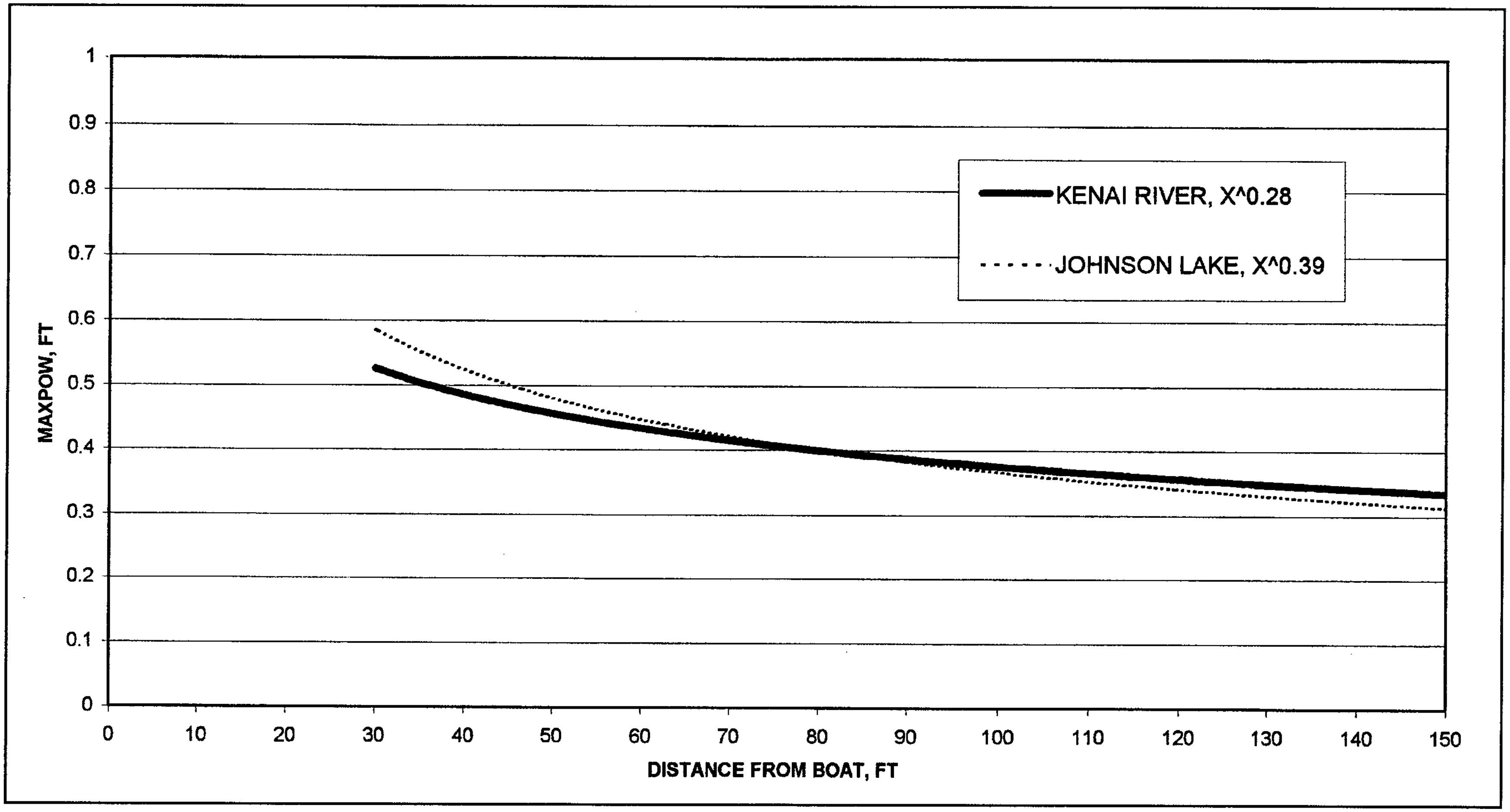


Figure 47. Comparison of MAXPOW decay with distance, hypothetical boat having same MAXPOW when averaged over all distances

to the currents will influence the degree to which wave current interactions are important.

Detecting Difference Between Means

At the planning stage of this study, it was estimated that five and eight replicates would be required on Johnson Lake and Kenai River to compare means of different loadings, motor powers, distance, and direction of travel (for tests on the Kenai River). If the comparison of means was based on two means each based on five or eight replicates, the minimum detectable differences would have been about 2 × standard deviation in Table 17 for five replicates and about 1.33 × standard deviation for eight replicates. In this study, the comparison of means was based on many combinations of loading, power, or distance and the detectable differences were less than a two-mean comparison based on only five or eight replicates. As an example, for each boat at Johnson Lake, motor power was compared at nine distances for each of three loadings, each having five replicates. The large number of tests along with relatively low standard deviations in Table 17 allowed determination of differences in means that were close together.

The tables showing the SNK also shows the critical range from SNK for differences between means which is the difference that must exist between adjacent means in a rank-ordered list of means before they are considered different. For the Johnson Lake MAXPOW tests, the typical critical range is about 0.02-0.03 ft. For the Johnson Lake MAXWAV tests, the typical critical range is about 0.025-0.04 ft. For the Kenai River MAXPOW tests, the typical critical range is about 0.02-0.03 ft. For the Kenai River MAXWAV tests, the typical critical range is about 0.05-0.08 ft.

9 Conclusions

Boat wave measurements on Johnson Lake and Kenai River compared wave characteristics of five boats at Johnson Lake and two boats at Kenai River under a variety of loadings, speeds, distances, motor powers, and direction of travel. A total of 596 tests were run on Johnson Lake and 284 tests on the Kenai River. Two wave types were measured. MAXPOW was the wave height at the maximum power of the motor. MAXWAV was the maximum wave height produced by the boat which required runs at a range of speeds to determine the MAXWAV. At Johnson Lake, MAXPOW for all conditions ranged from 0.14 to 0.99 ft. At Kenai River, the MAXPOW for all conditions ranged from 0.22 to 1.07 ft. Subsequent paragraphs discuss wave changes in percentages such as a 10- or 20-percent reduction. The reader should note that percentages are often the result of modest changes in the absolute magnitude of MAXPOW or MAXWAV. Summary and conclusions based on the measurements follow.

Effect of Motor Power

Johnson Lake boats with 35-hp motors produced larger wave energy (Figure 46) and MAXPOW (Table 19a) than boats with 40- or 50-hp motors except for the Lowe which produced about equal wave heights and energies with the 40-hp motor. The WP at Johnson Lake produced a 20-percent reduction in MAXPOW with the 50-hp motor compared to the 35 hp. The Koeffler produced a 15-percent reduction with the 50 hp, the Klamath produced a 12-percent reduction with the 40 hp, and the Lowe produced no significant change with the 40-hp motor when compared to the 35 hp. On the Kenai River (Table 26), the WP with a 50-hp motor reduced MAXPOW by 12 percent when compared to a 35-hp motor. The KF produced no significant difference with the two motors. The largest difference due to power was the Willie Predator which is a result of the 35-hp motor producing a speed close to the speed causing the MAXWAV.

Effect of Boat

At Johnson Lake, the Willie Predator produced the largest wave energy (Figure 46) and MAXPOW (Table 19c). The average WP MAXPOW for a common power of 35 hp and common loadings of three and four people was 0.59 ft when averaged over all distances. The Koeffler and Klamath produced similar MAXPOW and wave energies that were less than the Willie Predator. Average

MAXPOW from the KF and KL for common power and loading was 0.34 and 0.39 ft, respectively. The Lowe produced the lowest wave height and energy of the boats tested having an average MAXPOW of 0.24 ft. At the Kenai River, the WP and KF MAXPOW for 35 hp averaged 0.61 and 0.39 ft, respectively over all effects (six passengers only). The 50-hp Aleckson with three passengers produced wave height comparable to the average of waves from the Klamath with three passengers. The MAXWAV was similar for the WP and KL at Johnson Lake. All other boats were different. The WP MAXWAV averaged 22 percent greater than the KF MAXWAV at both Johnson Lake (Table 22) and the Kenai River (Table 28b) when averaged over both directions at Kenai River.

Effect of Hull Type

While other differences cannot be ruled out, hull type is the most apparent difference between two boat groups that exhibit differences in wave characteristics. With the existing 35-hp motors and equal number of passengers in the boats (three and four), the V-hull boats (WP&KL) produced a MAXPOW 66 percent greater than the flat-bottomed boats (KF&LW) because of the difference in hull shape and their greater total weight. With the existing 35-hp motors and equal total weight of the boats, the V-hull boat had an average MAXPOW 29 percent greater than the flat-bottomed boats. Nomographs of MAXPOW for the two hull types are given in Figures 33 and 34 and show that differences in hull type diminish with increasing power/weight when all the data are considered.

Effect of Direction of Boat on Kenai River

The MAXPOW was similar for upstream and downstream directions (Figures 41 and 42). The wave period was greater for upbound than downbound boats. The energy for the MAXPOW tests was greater for the upbound boats because of the greater period. The MAXWAV was larger for upstream boats with the WP upstream boat wave 24 percent larger than the downstream and the KF upstream boat wave 15 percent larger than the downstream.

Effect of Wave Type

The MAXWAV was larger than the MAXPOW for all boats. At Johnson Lake using common distances of 4-9, 35 hp, and average of all loads, the MAXWAV was 12, 60, 74, and 166 percent greater than the MAXPOW for the WP, KF, KL, and LW, respectively. At Kenai River using common distances 1-6, the MAXWAV was 38 and 66 percent greater than the MAXPOW 35 hp for the WP and KF, respectively for upbound boats and 7 and 43 percent greater than downbound boats. Typical speed at which the MAXWAV occurred was about 9 mph relative to water. Wave period was higher for the MAXWAV than the MAXPOW, particularly for the upstream heading boats on the Kenai River.

Effect of Location (Lake or River)

MAXPOW averaged over all distances was similar at Johnson Lake and Kenai River. Using a loading of six passengers only, the MAXPOW at Johnson Lake averaged over all effects was 0.62 and 0.38 ft for the WP and KF, respectively. Using a loading of six passengers only, the MAXPOW at Kenai River averaged overall effects was 0.57 and 0.39 ft for the WP and KF, respectively. The lake and river were different regarding decay of MAXPOW as discussed subsequently under effect of distance. When averaged over common distances 4-6 and using six-passenger loading only, MAXWAV was larger at the Kenai River than at Johnson Lake for upstream runs and mixed results for the downstream runs. The WP had average MAXWAV of 0.65 ft at Johnson Lake vs. 0.55 ft for the downstream runs and 0.75 ft for the upstream runs. The KF had average MAXWAV of 0.49 ft at Johnson Lake vs. 0.51 ft for the downstream runs and 0.62 ft for the upstream runs.

Effect of Load

All boats showed increasing MAXPOW with increasing load. The Willie Predator produced the greatest increase in MAXPOW, likely as a result of the larger loads resulting in speeds close to the MAXWAV speed. Based on Table 19b, the change in loading from heavy (six or five passengers) to light (three passengers) resulted in an average decrease in MAXPOW of 22 percent. The change in loading from heavy to medium (four passengers) resulted in an average decrease in MAXPOW of 10 percent. Loading changes produced only small changes in the MAXWAV tests (Figure 36).

Effect of Distance

All boats showed decreasing wave height with distance from the boat. The average slope (exponent) of the power function equation from the regression equations and Plates 8-26 for all MAXPOW tests is $X^{-0.40}$. At Kenai River the MAXPOW tests resulted in an average slope of $X^{-0.29}$ indicating a faster decay rate at Johnson Lake.

Areas Needing Additional Study

While this study answered many questions regarding boat waves from Kenai River boats, the study identified other areas that remain unanswered, including the following:

a. If MAXWAV is an important issue with the resource agencies, additional study is needed of the upstream MAXWAV in the Kenai River. This wave contained wave energies much greater than other wave types and conditions. Wave measurements need to be made during periods of peak

boating activity to determine the frequency of occurrence of these waves having large periods and thus large energies.

b. This study intentionally placed wave gages in depths large enough to minimize bottom effects. Information is needed on how wave characteristics are affected by nearshore bathymetry.

c. Wave data are needed to determine how significant trim is in defining wave height. Collection of trim data only for the boats used in this study for the range of loads and motor powers used in this study would aid in better understanding of the data presented herein. These tests could be run without having to measure wave heights. Additional tests are needed in which the trim is varied by different loading patterns along with concurrent wave height measurements.

d. What happens on the river when boat activity is large and waves are coming from numerous sources? The measurements described in item 1 would provide this data.

e. What is the combined effect of waves and currents on bank erosion?

f. What is the effect of the waves measured in this investigation on the magnitude of bank erosion on the various bank types of the Kenai River?

Table 1
Ambient Conditions at Kenai River Site

Date:time	Discharge (cfs)[1]: average channel velocity[3] (ft/sec)	Depth (ft): depth-averaged velocity[2] (ft/sec): surface velocity (ft/sec)				
		Gage 1	Gage 3	SL 1	SL 2	SL 3
8/01:1230	12,600: 5.37	5.7:4.1:NA	7.7:4.5:NA	7.8:5.5:NA	7.8:5.5:NA	8.3:6.1:NA
8/01:2130	13,300:5.4	7.0:4.0:4.3	7.9:4.7:5.8	8.0:5.3:7.7	8.1:5.7:7.7	8.5:6.1:8.0
8/02:1000	13,700:5.5	7.1:4.1:4.4	8.3:4.7:6.1	8.2:5.8:7.1	8.4:6.1:7.9	8.6:6.1:7.8
8/02:2000	13,850:5.6	7.9:4.1:4.4	8.2:4.6:5.5	8.3:5.8:6.7	8.3:5.8:7.7	8.8:6.1:7.6
8/03:0730	14,000:5.6	7.1:4.0:4.6	7.8:4.8:5.8	8.0:5.9:6.4	8.0:6.3:6.8	8.7:6.1:6.6

[1] cfs = cubic feet of water per second.
[2] Depth-averaged velocity- velocity measured at 60% of depth below the surface.
[3] Average channel velocity = discharge/channel cross-sectional area.

Table 2
Calibrations Used in Johnson Lake and Kenai River

Date:time	Cal name[1]	Gages calibrated	Description
7/23:1555-1636	L#-C1	1,2,3,4	Beginning calibration at lake
7/25:1122-1126	L#-C2	1,2,3,4	In-progress calibration
7/27:0950-0955	L#-C3	1,2,3,4	In-progress calibration
7/29:1645-1649	L#-C4	1,2,3,4	End calibration at lake
7/31:1922-1925	R#-C1	1,2,3,4	Beginning calibration at river
8/01:1304	R#-C1B	3	Calibration after broken wire
8/02:0834	R#-C2	3	In-progress calibration
8/02:0850	R#-C2B	3	Calibration after broken wire
8/03:0848	R#-C3	3	In-progress calibration
8/03:0846	R#-C2	4	In-progress calibration, found condensation
8/03:0847	R#-C3	4	Further test of Gage 4
8/03:0857	R#-C4	4	Calibration of new Gage 4
8/03:1228	R#-C5	4	Calibration after broken wire
8/03:19:32-1935	R#-C10	1,2,3,4	In-place calibration
8/03:2032-2034	R#-C11	1,2,3,4	End calibration on river

[1] L=lake calibration, R = river calibration, # = gage number.

Table 3
Johnson Lake Boatwake Investigations, Willie Predator, 35 hp, MAXPOW and MAXWAV Tests

Date: 7/24/00

MAXPOW Test

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of Maximum Wave, Sec Gage 1	Gage 2	Gage 3	Gage 4
plot	JWP24-41	1	1446	6	15.0	16.0	0.748	0.859	0.817	0.86	1.48	1.36	1.84	1.88
	JWP24-42	1	1452	6	14.4	16.0	0.718	0.878	0.788	0.749	1.52	1.36	1.48	1.92
	JWP24-43	1	1458	6	14.1	16.0	0.764	0.86	0.941	0.951	1.4	1.28	1.68	1.68
	JWP24-44	1	1503	6	14.4	15.0	0.744	0.703	0.974	0.987	1.28	1.48	1.36	1.52
	JWP24-45	1	1508	6	14.1	15.0	0.725	0.892	0.798	0.801	1.56	1.44	1.16	1.44
Average					14.4	15.6	0.7398	0.8384	0.8636	0.8696	1.448	1.384	1.504	1.688
Std. Dev.					0.367	0.548	0.01847	0.07692	0.08713	0.09969				
	JWP24-46	2	1517	6	14.8	15.0	0.614	0.67	0.713	0.708	1.4	1.4	1.56	1.56
	JWP24-47	2	1522	6	14.7	16.0	0.608	0.629	0.667	0.647	1.56	1.48	1.68	1.52
	JWP24-48	2	1527	6	14.4	15.0	0.59	0.658	0.722	0.664	1.6	1.36	1.68	1.48
plot	JWP24-49	2	1534	6	14.3	16.0	0.607	0.643	0.703	0.671	1.56	1.4	1.48	1.36
	JWP24-50	2	1538	6	14	16.0	0.587	0.614	0.663	0.657	1.6	1.6	1.76	1.4
Average					14.44	15.6	0.6012	0.6428	0.6936	0.6694	1.544	1.448	1.632	1.464
Std. Dev.					0.321	0.548	0.01195	0.02231	0.027	0.02333				
	JWP24-51	3	1543	6	14.6	15.0	0.494	0.569	0.592	0.636	1.52	1.48	1.44	1.56
	JWP24-52	3	1548	6	14.6	15.0	0.501	0.531	0.567	0.573	1.6	1.44	1.4	1.52
plot	JWP24-53	3	1554	6	14.8	16.0	0.505	0.56	0.617	0.593	1.4	1.56	1.64	1.76
	JWP24-54	3	1559	6	15.0	15.0	0.535	0.583	0.613	0.645	1.52	1.48	1.56	1.56
	JWP24-55	3	1604	6	14.6	16.0	0.523	0.538	0.652	0.565	1.56	1.12	1.52	1.32
Average					14.72	15.4	0.5116	0.5562	0.6082	0.6024	1.52	1.416	1.512	1.544
Std. Dev.					0.179	0.548	0.01691	0.02158	0.03154	0.03638				
	JWP24-72	1	1845	4	19.4	15.0	0.765	0.792	0.908	0.924	1.48	1.16	1.44	1.48
	JWP24-73	1	1850	4	19.8	19.0	0.744	0.712	0.906	0.946	1.44	1.36	1.28	1.32
	JWP24-74	1	1854	4	19.6	19.0	0.751	0.729	0.908	0.951	1.4	1.36	1.12	1.4
	JWP24-75	1	1901	4	19.8	19.0	0.682	0.845	0.829	0.755	1.32	1.32	1.32	1.44
plot	JWP24-76	1	1905	4	19.5	19.0	0.722	0.785	0.873	0.84	1.4	1.2	1.4	1.52
Average					19.62	18.2	0.7328	0.7726	0.8848	0.8832	1.408	1.28	1.312	1.432
Std. Dev.					0.179	0.179	0.03237	0.05326	0.03456	0.08442				
plot	JWP24-77	2	1910	4	19.7	18.0	0.546	0.584	0.665	0.657	1.4	1.28	1.6	1.32
	JWP24-78	2	1914	4	19.2	15.0	0.519	0.581	0.654	0.67	1.48	1.56	1.52	1.36
	JWP24-79	2	1919	4	19.6	16.0	0.537	0.544	0.643	0.657	1.4	1.32	1.36	1.48
	JWP24-80	2	1923	4	19.7	17.0	0.531	0.618	0.656	0.656	1.48	1.4	1.48	1.36
	JWP24-81	2	1929	4	19.5	16.0	0.597	0.624	0.641	0.642	1.32	1.52	1.4	1.28
Average					19.54	16.4	0.546	0.5902	0.6518	0.6564	1.416	1.416	1.472	1.36
Std. Dev					0.207	1.14	0.03015	0.0323	0.00988	0.00991				
	JWP24-82	3	1944	4	19.2	18.0	0.511	0.538	0.528	0.616	1.36	1.52	1.44	1.48
	JWP24-83	3	1949	4	19.2	19.0	0.451	0.504	0.512	0.565	1.28	1.48	1.24	1.48
plot	JWP24-84	3	1953	4	19.5	19.0	0.524	0.491	0.551	0.606	1.48	1.72	1.36	1.36
	JWP24-85	3	1958	4	19.5	15.0	0.564	0.517	0.525	0.583	1.4	1.48	1.4	1.32
	JWP24-86	3	2002	4	19.7	19.0	0.478	0.522	0.544	0.539	1.44	1.28	1.44	1.44
Average					19.42	18.0	0.5056	0.5144	0.532	0.5818	1.392	1.496	1.376	1.416
Std. Dev.					0.217	1.732	0.04336	0.01787	0.01557	0.03111				
plot	JWP24-100	1	2130	3	21.3	14.0	0.548	0.608	0.777	0.767	1.4	1.24	1.44	1.4
	JWP24-101	1	2134	3	21.7	21.0	0.542	0.581	0.739	0.711	1.4	1.24	1.44	1.44
	JWP24-102	1	2138	3	21.5	21.0	0.523	0.612	0.735	0.662	1.44	1.28	1.44	1.48
	JWP24-103	1	2142	3	21.6	21.0	0.535	0.583	0.766	0.748	1.4	1.52	1.4	1.4
	JWP24-104	1	2146	3	21.4	21.0	0.586	0.612	0.798	0.781	1.28	1.48	1.32	1.32
Average					21.5	19.6	0.5468	0.5992	0.763	0.7338	1.384	1.352	1.408	1.408
Std. Dev.					0.158	3.13	0.02381	0.0158	0.02641	0.04798				
	JWP24-105	2	2150	3	21.8	21.0	0.415	0.444	0.478	0.505	1.36	1.36	1.32	1.32
	JWP24-106	2	2154	3	21.6	21.0	0.437	0.454	0.498	0.517	1.48	1.36	1.32	1.2
plot	JWP24-107	2	2157	3	21.5	21.0	0.435	0.472	0.495	0.507	1.36	1.4	1.48	1.48
	JWP24-108	2	2201	3	21.9	21.0	0.428	0.501	0.519	0.484	1.4	1.32	1.32	1.4
	JWP24-109	2	2204	3	21.6	21.0	0.442	0.461	0.527	0.54	1.36	1.4	1.4	1.44
Average					21.68	21.0	0.4314	0.4664	0.5034	0.5106	1.392	1.368	1.368	1.368
Std. Dev.					0.164	0.0	0.01045	0.02187	0.01965	0.02035				
	JWP24-110	3	2208	3	21.7	21.0	0.395	0.417	0.442	0.463	1.36	1.36	1.48	1.44

Table 3 (Continued)

Date: 7/24/00

MAXPOW Test (Continued)

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of Maximum Wave, Sec Gage 1	Gage 2	Gage 3	Gage 4
	JWP24-111	3	2212	3	21.6	21.0	0.42	0.424	0.436	0.453	1.36	1.32	1.44	1.44
plot	JWP24-112	3	2215	3	21.8	21.0	0.406	0.436	0.447	0.432	1.44	1.36	1.52	1.4
	JWP24-113	3	2219	3	21.4	21.0	0.414	0.449	0.458	0.442	1.44	1.4	1.44	1.32
	JWP24-114	3	2223	3	21.8	21.0	0.415	0.422	0.462	0.444	1.4	1.4	1.48	1.32
Average					21.66	21.0	0.41	0.4296	0.449	0.4468	1.4	1.368	1.472	1.384
Std. Dev.					0.167	0.0	0.00977	0.0129	0.01086	0.01173				
						MAXWAV Tests								
						Search for Maximum Wave								
	JWP24-56	2		6	9.1		0.54	0.607	0.644	0.714	1.88	1.68	1.6	1.68
	JWP24-57	2		6	9.7		0.573	0.634	0.711	0.624	1.92	1.8	1.72	1.64
	JWP24-58	2		6	11.2		0.571	0.531	0.669	0.641	1.52	1.52	1.64	1.88
	JWP24-59	2		6	11.5		0.574	0.569	0.643	0.687	1.48	1.68	1.6	1.52
	JWP24-60	2		6	13.0		0.662	0.637	0.758	0.696	1.44	1.68	1.44	1.72
	JWP24-61	2		6	14.0		0.625	0.636	0.717	0.671	1.4	1.44	1.56	1.24
	JWP24-62	2		6	12.7		0.579	0.608	0.675	0.674	1.36	1.48	1.6	1.48
						Maximum Wave Found at 13.0 mph								
	JWP24-60	***2***		***6***	***13.0***		0.662	0.637	0.758	0.696	1.44	1.68	1.44	1.72
	JWP24-63	2		6	13.1		0.582	0.618	0.655	0.64	1.6	1.52	1.84	1.36
plot	JWP24-64	2		6	13.0		0.6	0.607	0.703	0.713	1.56	1.72	1.44	1.4
	JWP24-65	2		6	12.5		0.542	0.575	0.628	0.661	1.56	1.96	1.96	1.52
	JWP24-66	2		6	12.8		0.651	0.663	0.719	0.671	1.48	1.64	1.8	1.36
Average					12.88		0.6074	0.62	0.6926	0.6762	1.528	1.704	1.696	1.472
Std. Dev.					0.239		0.04965	0.03292	0.05165	0.02879				
plot	JWP24-67	3		6	13.0		0.537	0.554	0.54	0.568	1.68	1.44	1.76	1.56
	JWP24-68	3		6	13.1		0.576	0.552	0.593	0.539	1.56	1.56	1.44	1.72
	JWP24-69	3		6	13.1		0.518	0.538	0.629	0.568	1.6	1.52	1.52	1.4
	JWP24-70	3		6	13.3		0.55	0.54	0.595	0.524	1.56	1.56	1.52	1.56
	JWP24-71	3		6	12.9		0.543	0.534	0.584	0.525	1.8	1.6	1.64	1.4
Average					13.08		0.5448	0.5436	0.5882	0.5448	1.64	1.536	1.576	1.528
Std. Dev.					0.148		0.02111	0.00888	0.03192	0.02199				
						Search for Maximum Wave								
	JWP24-87	2		4	11.0		0.575	0.612	0.715	0.675	1.56	1.96	1.48	1.4
	JWP24-88	2		4	9.2		0.592	0.659	0.738	0.757	2.04	1.64	1.68	1.72
	JWP24-89	2		4	8.1		0.438	0.48	0.502	0.514	1.44	2.0	1.68	1.68
	JWP24-90	2		4	10.0		0.554	0.614	0.691	0.696	1.64	1.52	1.88	1.76
						Maximum Wave Found at 9.2 mph								
	JWP24-88	***2***		***4***	***9.2***		0.592	0.659	0.738	0.757	2.04	1.64	1.68	1.72
plot	JWP24-91	2		4	9.7		0.56	0.67	0.711	0.679	2.08	1.76	1.48	1.84
	JWP24-92	2		4	9.3		0.558	0.633	0.667	0.646	2	1.76	1.8	1.92
	JWP24-93	2		4	9.4		0.577	0.615	0.726	0.683	1.76	1.88	1.64	1.8
	JWP24-94	2		4	9.2		0.54	0.647	0.732	0.73	1.68	1.72	1.84	1.72
Average					9.36		0.5654	0.6448	0.7148	0.699	1.912	1.752	1.688	1.8
Std. Dev.					0.207		0.01982	0.02161	0.02854	0.04413				
	JWP24-95	3		4	9.2		0.495	0.555	0.618	0.685	1.84	1.92	1.88	1.8
	JWP24-96	3		4	9.3		0.521	0.532	0.619	0.685	2.04	1.76	1.96	1.76
	JWP24-97	3		4	9.1		0.486	0.515	0.566	0.579	1.92	1.64	1.96	1.52
	JWP24-98	3		4	9.2		0.453	0.488	0.553	0.58	1.8	1.96	1.68	1.64
plot	JWP24-99	3		4	9.2		0.474	0.513	0.589	0.617	1.96	1.92	1.68	1.72
Average					9.2		0.4858	0.5206	0.589	0.6292	1.912	1.84	1.832	1.688
Std. Dev.					0.07		0.02519	0.02483	0.02986	0.05319				
						Search for Maximum Wave								
	JWP24-115	2		3	8.7		0.579	0.578	0.592	0.596	1.72	1.68	1.6	1.8
	JWP24-116	2		3	11.6		0.588	0.616	0.716	0.724	1.52	1.48	1.68	1.68
	JWP24-117	2		3	12.0		0.595	0.612	0.686	0.665	1.48	1.48	1.68	1.68
	JWP24-118	2		3	10.2		0.521	0.593	0.683	0.635	1.68	1.64	1.64	1.6

(Sheet 2 of 3)

Table 3 (Concluded)

Date: 7/24/00														
MAXWAV Test (Continued)														
	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft				Period of Maximum Wave, Sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
Maximum Wave Found at 11.6 mph														
	JWP24-116	2		3	11.6		0.588	0.616	0.716	0.724	1.52	1.48	1.68	1.68
	JWP24-119	2		3	11.7		0.579	0.59	0.688	0.678	1.48	1.6	1.52	1.44
plot	JWP24-120	2		3	12.0		0.59	0.602	0.663	0.676	1.44	1.48	1.44	1.68
	JWP24-121	2		3	11.2		0.58	0.607	0.688	0.689	1.52	1.6	1.56	1.56
	JWP24-122	2		3	11.7		0.635	0.637	0.688	0.676	1.48	1.48	1.76	1.72
Average					11.64		0.5944	0.6104	0.6886	0.6886	1.488	1.528	1.592	1.616
Std. Dev.					0.288		0.0232	0.01759	0.01876	0.02051				
	JWP24-123	3		3	11.9		0.489	0.502	0.542	0.559	1.56	1.64	1.6	1.48
	JWP24-124	3		3	11.6		0.52	0.528	0.574	0.564	1.56	1.64	1.6	1.44
	JWP24-125	3		3	11.6		0.519	0.53	0.567	0.551	1.52	1.64	1.56	1.52
plot	JWP24-126	3		3	11.3		0.52	0.518	0.571	0.571	1.6	1.52	1.64	1.48
	JWP24-127	3		3	11.6		0.492	0.499	0.551	0.593	1.6	1.56	1.64	1.48
Average					11.6		0.508	0.5154	0.561	0.5676	1.568	1.6	1.608	1.48
Std. Dev.					0.212		0.01602	0.01438	0.01384	0.01596				

(Sheet 3 of 3)

Table 4
Johnson Lake Boatwake Investigations, Willie Predator, 50 hp, MAXPOW Tests

Date: 7/23/00-7/24/00

MAXPOW Tests

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum wave height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of maximum wave, sec Gage 1	Gage 1	Gage 3	Gage 4
	JWP23-1	1	1934	6	25.0	17.0	0.543	0.705	0.642	0.713	1.16	1.2	1.4	1.36
	JWP23-2	1	1942	6		24.0	0.544	0.679	0.677	0.698	1.44	1.28	1.56	1.64
	JWP23-3	1	1952	6	25.1	24.0	0.51	0.612	0.695	0.712	1.28	1.48	1.24	1.2
	JWP23-4	1	1958	6	25.2	25.0	0.581	0.608	0.816	0.804	1.32	1.48	1.2	1.4
plot	JWP23-5	1	2009	6	24.8	24.0	0.593	0.66	0.672	0.714	1.52	1.56	1.68	1.48
	JWP23-6	1	2017	6		24.0	0.627	0.781	0.747	0.9	1.44	1.36	1.68	1.56
	JWP23-7	1	2024	6		25.0	0.542	0.694	0.683	0.73	1.52	1.36	1.24	1.48
	JWP23-8	1	2037	6		25.0	0.549	0.659	0.69	0.678	1.32	1.32	1.28	1.32
	JWP23-9	1	2043	6		25.0	0.612	0.762	0.728	0.843	1.44	1.28	1.84	1.56
	JWP23-10	1	2048	6		24.0	0.579	0.584	0.76	0.737	1.44	1.44	1.08	1.2
Average					25.025	23.7	0.568	0.6744	0.711	0.7529	1.388	1.376	1.42	1.42
Std. Dev.					0.171	2.41	0.03641	0.06438	0.05156	0.07192				
	JWP24-1	2	0824	6	25.4	25.0	0.418	0.479	0.53	0.533	1.44	1.36	1.44	1.4
	JWP24-2	2	0830	6	25.4	25.0	0.448	0.492	0.526	0.545	1.36	1.44	1.44	1.4
plot	JWP24-3	2	0835	6	25.1	25.0	0.443	0.472	0.546	0.572	1.36	1.44	1.4	1.32
	JWP24-4	2	0840	6	25.2	25.0	0.456	0.503	0.559	0.556	1.4	1.48	1.4	1.4
	JWP24-5	2	0844	6	25.2 .	19.0	0.447	0.499	0.542	0.523	1.4	1.32	1.44	1.4
Average					25.26	23.8	0.4424	0.489	0.5406	0.5458	1.392	1.408	1.424	1.384
Std. Dev.					0.134	2.68	0.01443	0.01317	0.01318	0.0192				
plot	JWP24-6	3	0851	6	25.1	24.0	0.406	0.387	0.454	0.472	1.4	1.32	1.36	1.32
	JWP24-7	3	0855	6	25.1	24.0	0.407	0.42	0.448	0.494	1.4	1.36	1.36	1.24
	JWP24-8	3	0900	6	25.2	25.0	0.383	0.392	0.45	0.436	1.44	1.36	1.4	1.36
	JWP24-9	3	0905	6	25.2	24.0	0.415	0.415	0.426	0.453	1.4	1.36	1.36	1.28
	JWP24-10	3	0909	6	25.1	24.0	0.425	0.428	0.471	0.454	1.48	1.32	1.36	1.4
Average					25.14	24.2	0.4072	0.4084	0.4498	0.4618	1.424	1.344	1.368	1.32
Std. Dev.					0.055	0.447	0.01553	0.01795	0.0161	0.02205				
plot	JWP24-11	1	0928	3	27.4	27.0	0.47	0.534	0.657	0.627	1.32	1.4	1.2	1.16
	JWP24-12	1	0933	3	27.3	27.0	0.457	0.528	0.671	0.666	1.28	1.4	1.24	1.16
	JWP24-13	1	0937	3	27.3	27.0	0.456	0.513	0.668	0.674	1.32	1.4	1.2	1.16
	JWP24-14	1	0940	3	27.3	27.0	0.457	0.556	0.615	0.607	1.28	1.36	1.16	1.16
	JWP24-15	1	0945	3	27.2	26.0	0.481	0.54	0.632	0.626	1.24	1.36	1.16	1.16
Average					27.3	26.8	0.4642	0.5342	0.6486	0.64	1.288	1.384	1.192	1.16
Std.Dev.					0.07	0.45	0.01103	0.01579	0.02425	0.02866				
plot	JWP24-16	2	0950	3	27.3	27.0	0.323	0.35	0.39	0.398	1.4	1.44	1.32	1.28
	JWP24-17	2	0955	3	27.2	27.0	0.325	0.341	0.382	0.413	1.32	1.4	1.48	1.28
	JWP24-18	2	1000	3	27.2	27.0	0.321	0.354	0.379	0.359	1.4	1.36	1.28	1.32
	JWP24-19	2	1010	3	27.2	27.0	0.305	0.343	0.394	0.403	1.36	1.36	1.32	1.32
	JWP24-20	2	1014	3	27.2	27.0	0.321	0.347	0.391	0.413	1.44	1.32	1.28	1.36
Average					27.22	27.0	0.319	0.347	0.3872	0.3972	1.384	1.376	1.336	1.312
Std. Dev.					0.045	0.0	0.008	0.00524	0.00638	0.02232				
	JWP24-21	3	1021	3	27.4	27.0	0.274	0.296	0.306	0.373	1.32	1.4	1.28	1.28
plot	JWP24-22	3	1026	3	27.3	27.0	0.296	0.317	0.335	0.336	1.28	1.4	1.32	1.36
	JWP24-23	3	1033	3	27.3	27.0	0.293	0.307	0.337	0.329	1.32	1.4	1.28	1.28
	JWP24-24	3	1038	3	27.3	26.0	0.294	0.304	0.322	0.329	1.32	1.44	1.28	1.32
	JWP24-25	3	1044	3	27.2	26.0	0.285	0.285	0.327	0.331	1.4	1.44	1.32	1.36
Average					27.3	26.6	0.2884	0.3018	0.3254	0.3396	1.328	1.416	1.296	1.32

(Continued)

Table 4 (Concluded)														
Date: 7/23/00-7/24/00														
MAXPOW Tests (Continued)														
	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum wave height, ft				Period of maximum wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 1	Gage 3	Gage 4
Std. Dev.					0.07	0.551	0.00907	0.01203	0.01242	0.01889				
	JWP24-26	1	1132	4	26.3	26.0	0.486	0.696	0.665	0.656	1.2	1.32	1.64	1.56
	JWP24-27	1	1137	4	26.3	26.0	0.533	0.65	0.633	0.624	1.28	1.32	1.2	1.68
plot	JWP24-28	1	1141	4	26.0	25.0	0.538	0.629	0.725	0.682	1.28	1.36	1.16	1.16
	JWP24-29	1	1146	4	26.5	26.0	0.507	0.543	0.757	0.737	1.32	1.48	1.24	1.24
	JWP24-30	1	1150	4	26.3	25.0	0.531	0.641	0.666	0.64	1.24	1.32	1.16	1.16
Average					26.28	25.6	0.519	0.6318	0.6892	0.6678	1.264	1.36	1.28	1.36
Std. Dev.					0.181	0.548	0.02199	0.05575	0.0504	0.04422				
	JWP24-31	2	1155	4	26.3	23.0	0.378	0.405	0.469	0.453	1.44	1.36	1.44	1.28
	JWP24-32	2	1200	4	26.2	20.0	0.382	0.425	0.465	0.487	1.28	1.36	1.44	1.4
plot	JWP24-33	2	1205	4	26.4	24.0	0.396	0.438	0.48	0.468	1.4	1.36	1.4	1.4
	JWP24-34	2	1210	4	26.3	26.0	0.398	0.449	0.499	0.465	1.28	1.32	1.4	1.4
	JWP24-35	2	1215	4	26.4	26.0	0.381	0.418	0.478	0.463	1.44	1.32	1.4	1.44
Average					26.32	23.8	0.387	0.427	0.4782	0.4672	1.368	1.344	1.416	1.384
Std. Dev.					0.084	2.491	0.00927	0.01713	0.01318	0.01242				
	JWP24-36	3	1222	4	26.4	26.0	0.333	0.345	0.368	0.4	1.4	1.4	1.32	1.28
	JWP24-37	3	1227	4	26.2	22.0	0.365	0.347	0.403	0.388	1.36	1.44	1.4	1.28
	JWP24-38	3	1232	4	26.2	23.0	0.341	0.35	0.369	0.378	1.4	1.4	1.32	1.32
plot	JWP24-39	3	1237	4	26.2	26.0	0.348	0.345	0.372	0.383	1.4	1.36	1.32	1.36
	JWP24-40	3	1246	4	26.0	25.0	0.416	0.411	0.416	0.384	1.4	1.36	1.44	1.4
Average					26.2	24.4	0.3606	0.3596	0.3856	0.3866	1.392	1.392	1.36	1.328
Std. Dev.					0.141	1.817	0.03314	0.02881	0.02235	0.00829				

Table 5
Johnson Lake Boatwake Investigations, Koeffler, 35 hp, MAXPOW and MAXWAV Tests

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft				Period of Maximum Wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
Date: 7/27/00														
MAXWAV Tests														
Search for Maximum Wave:														
	JKF27-1	2		5	9.1		0.455	0.45	0.58	0.579	1.76	2.04	1.68	1.64
	JKF27-2	2		5	8.0		0.472	0.497	0.61	0.524	1.68	1.76	1.8	1.96
	JKF27-3	2		5	7.2		0.316	0.326	0.357	0.361	1.32	1.32	1.44	1.76
	JKF27-4	2		5	9.8		0.422	0.448	0.538	0.535	1.72	1.76	1.72	1.56
	JKF27-5	2		5	11.9		0.388	0.414	0.475	0.47	1.56	1.68	1.44	1.44
	JKF27-6	2		5	8.6		0.447	0.494	0.56	0.599	1.72	1.76	1.92	1.8
Note that tests 1 to 6 were run in error with 5 loads.														
	JKF27-7	2		6	8.6		0.449	0.471	0.558	0.534	1.84	1.92	1.56	1.88
	JKF27-8	2		6	9.5		0.47	0.533	0.515	0.523	1.88	1.84	1.92	1.88
	JKF27-9	2		6	7.7		0.316	0.335	0.371	0.346	1.8	2.08	1.8	0.84
	JKF27-10	2		6	9.0		0.401	0.454	0.455	0.536	1.6	1.88	2.04	1.84
	JKF27-11	2		6	10.7		0.377	0.44	0.464	0.48	1.96	1.68	2.12	1.88
	JKF27-12	2		6	8.2		0.462	0.49	0.49	0.444	1.68	1.72	1.56	1.76
8.6 mph selected														
	JKF27-7	2		6	8.6		0.449	0.471	0.558	0.534	1.84	1.92	1.56	1.88
	JKF27-13	2		6	8.6		0.481	0.529	0.528	0.506	1.56	1.68	2.08	1.8
	JKF27-14	2		6	8.7		0.452	0.505	0.534	0.502	1.88	1.76	1.88	1.56
plot	JKF27-15	2		6	8.7		0.426	0.471	0.522	0.523	1.72	1.8	1.72	1.88
	JKF27-16	2		6	8.5		0.42	0.431	0.516	0.506	2	1.64	1.96	1.64
Average					8.62		0.4456	0.4814	0.5316	0.5142	1.8	1.76	1.84	1.752
Std dev					0.08367		0.02421	0.03735	0.01621	0.01372				
	JKF27-17	3		6	8.5		0.42	0.453	0.468	0.461	2	1.88	1.76	1.84
plot	JKF27-18	3		6	8.4		0.381	0.463	0.48	0.506	1.52	1.64	1.6	1.92
	JKF27-19	3		6	8.5		0.394	0.42	0.487	0.512	1.64	1.92	1.64	1.56
	JKF27-20	3		6	8.7		0.448	0.48	0.47	0.523	1.96	1.88	1.8	1.76
	JKF27-21	3		6	8.6		0.365	0.446	0.505	0.524	1.96	1.96	1.44	1.52
Average					8.54		0.4016	0.4524	0.482	0.5052	1.816	1.856	1.648	1.72
Std dev					0.11402		0.03284	0.02217	0.01498	0.02584				
MAXPOW Tests														
plot	JKF27-22	1	1219	6	22.4	21.0	0.432	0.501	0.613	0.577	1.36	1.4	1.4	1.4
	JKF27-23	1	1223	6	22.5	22.0	0.464	0.558	0.613	0.561	1.4	1.44	1.16	1.16
	JKF27-24	1	1227	6	22.5	22.0	0.395	0.469	0.576	0.588	1.44	1.64	1.48	1.56
	JKF27-25	1	1233	6	22.4	22.0	0.405	0.441	0.612	0.652	1.68	1.24	1.36	1.32
	JKF27-26	1	1236	6	22.6	22.0	0.369	0.466	0.583	0.568	1.28	1.4	1.48	1.4
Average					22.48	21.8	0.413	0.487	0.5994	0.5892	1.432	1.424	1.376	1.368
Std. Dev.					0.084	0.447	0.03635	0.04505	0.01834	0.03653				
	JKF27-27	2	1240	6	22.3	21.0	0.32	0.396	0.384	0.422	1.72	1.32	1.2	1.44
	JKF27-28	2	1243	6	22.3	22.0	0.341	0.395	0.468	0.418	1.64	1.56	1.64	1.4
plot	JKF27-29	2	1246	6	22.4	22.0	0.361	0.38	0.388	0.39	1.64	1.52	1.76	1.48
	JKF27-30	2	1248	6	22.2	22.0	0.423	0.408	0.39	0.447	1.44	1.48	1.6	1.56
	JKF27-31	2		6	22.4	22.0	0.317	0.355	0.384	0.432	1.28	1.64	1.52	1.36
Average					22.32	21.8	0.3524	0.3868	0.4028	0.4218	1.544	1.504	1.544	1.448
Std. Dev.					0.084	0.447	0.04328	0.02036	0.03654	0.021				
plot	JKF27-32	3	1254	6	22.2	22.0	0.311	0.356	0.334	0.335	1.52	1.36	1.44	1.52

(Continued)

Table 5 (Concluded)

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of Maximum Wave, sec Gage 1	Gage 2	Gage 3	Gage 4
Date: 7/27/00														
MAXPOW Tests														
	JKF27-33	3	1257	6	21.8	21.0	0.299	0.323	0.342	0.365	1.56	1.56	1.56	1.52
	JKF27-34	3	1300	6	22.0	21.0	0.282	0.317	0.327	0.375	1.32	1.4	1.76	1.64
	JKF27-35	3	1303	6	22.3	22.0	0.245	0.275	0.341	0.347	1.72	1.28	1.48	1.4
	JKF27-36	3		6	22.3	21.0	0.351	0.341	0.358	0.308	1.52	1.48	1.56	1.28
Average					22.12	21.4	0.2976	0.3224	0.3404	0.346	1.528	1.416	1.56	1.472
Std. Dev.					0.217	0.548	0.03887	0.03062	0.01155	0.02631				
	JKF27-37	1	1402	4	23.6	23.0	0.382	0.449	0.575	0.578	1.52	1.36	1.36	1.28
	JKF27-38	1	1404	4	23.6	23.0	0.454	0.539	0.515	0.513	1.8	1.44	0.92	1.24
	JKF27-39	1	1406	4	23.7	23.0	0.497	0.575	0.561	0.599	1.48	1.64	1.36	1.32
	JKF27-40	1	1409	4	23.7	24.0	0.417	0.44	0.594	0.501	1.16	1.32	1.28	1.48
plot	JKF27-41	1	1412	4	23.6	23.0	0.449	0.49	0.55	0.512	1.6	1.28	1.12	0.96
Average					23.64	23.2	0.4398	0.4986	0.559	0.5406	1.512	1.408	1.208	1.256
Std. Dev.					0.055	0.447	0.04307	0.05796	0.02959	0.0446				
	JKF27-42	2	1414	4	23.4	22.0	0.306	0.34	0.409	0.391	1.08	1.32	1.6	1.36
	JKF27-43	2	1416	4	23.7	23.0	0.378	0.311	0.412	0.352	1.4	1.24	1.64	1.52
	JKF27-44	2	1418	4	23.5	24.0	0.241	0.262	0.316	0.34	1.56	1.52	1.48	1.12
	JKF27-45	2	1422	4	23.4	23.0	0.271	0.263	0.309	0.319	1.36	1.08	1.4	1.32
plot	JKF27-46	2	1424	4	23.3	23.0	0.253	0.261	0.324	0.356	1.32	1.32	1.52	1.28
Average					23.46	23	0.2898	0.2874	0.354	0.3516	1.344	1.296	1.528	1.32
Std. Dev.					0.152	0.707	0.05507	0.03627	0.05186	0.02631				
	JKF27-47	3	1428	4	23.6	23.0	0.308	0.311	0.336	0.338	1.6	1.56	1.36	1.52
plot	JKF27-48	3	1434	4	23.3	23.0	0.283	0.285	0.332	0.323	1.2	0.84	1.6	1.56
	JKF27-49	3	1439	4	23.4	23.0	0.267	0.27	0.301	0.31	1.52	0.6	1.68	1.44
	JKF27-50	3	1508	4	23.4	22.0	0.25	0.246	0.262	0.303	1.48	1.68	1.04	1.32
	JKF27-51	3	1511	4	23.7	23.0	0.231	0.271	0.268	0.31	1.36	1.48	1.6	1.36
Average					23.48	22.8	0.2678	0.2766	0.2998	0.3168	1.432	1.232	1.456	1.44
Std. Dev.					0.164	0.447	0.02966	0.0238	0.0346	0.01388				
	JKF27-52	1	1536	3	25.3	25.0	0.325	0.362	0.479	0.466	1.16	1.6	1.2	1.24
plot	JKF27-53	1	1540	3	25.2	24.0	0.321	0.361	0.423	0.426	1.36	1.16	1.2	1.48
	JKF27-54	1	1542	3	25.1	24.0	0.31	0.377	0.466	0.425	1.32	1.36	1.48	1.44
	JKF27-55	1	1545	3	25.1	24.0	0.336	0.352	0.479	0.413	1.56	1.24	1.56	1.2
	JKF27-56	1	1548	3	25.4	25.0	0.281	0.365	0.407	0.428	1.32	1.44	1.12	1.28
Average					25.22	24.4	0.3146	0.3634	0.4508	0.4316	1.344	1.36	1.312	1.328
Std. Dev.					0.13	0.548	0.02096	0.00902	0.03359	0.02011				
	JKF27-57	2	1551	3	25.3	25.0	0.245	0.279	0.327	0.289	1.44	1.36	1.44	1.72
	JKF27-58	2	1554	3	25.3	25.0	0.267	0.281	0.291	0.308	1.72	1.56	1.6	1.64
plot	JKF27-59	2	1600	3	25.2	25.0	0.279	0.282	0.351	0.355	1.52	1.48	1.56	1.44
	JKF27-60	2	1603	3	25.0	24.0	0.28	0.285	0.348	0.338	1.28	1.52	1.6	1.44
	JKF27-61	2	1606	3	25.0	24.0	0.234	0.243	0.25	0.325	1.44	1.68	1.88	1.64
Average					25.16	24.6	0.261	0.274	0.3134	0.323	1.48	1.52	1.616	1.576
Std. Dev.					0.152	0.584	0.02065	0.01746	0.04277	0.02566				
	JKF27-62	3	1608	3	25.4	25.0	0.227	0.251	0.268	0.272	1.52	1.36	1.28	1.52
	JKF27-63	3	1611	3	25.3	25.0	0.216	0.229	0.279	0.226	1.36	1.4	1.48	1.36
plot	JKF27-64	3	1614	3	25.3	24.0	0.207	0.269	0.242	0.26	1.44	1.6	1.28	1.64
	JKF27-65	3	1618	3	25.0	24.0	0.251	0.266	0.272	0.273	1.6	1.2	1.6	1.52
	JKF27-66	3	1620	3	25.4	25.0	0.22	0.231	0.247	0.259	1.64	1.68	2.24	1.76
Average					25.28	24.6	0.2242	0.2492	0.2616	0.258	1.512	1.448	1.576	1.56
Std. Dev.					0.164	0.548	0.01663	0.01882	0.0162	0.01904				

Table 6
Johnson Lake Boatwake Investigations, Koeffler, 50 hp, MAXPOW and MAXWAV Tests

Date: 7/25/00

MAXPOW Tests

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft				Period of maximum wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	JKF25-1	1	1214	6	25.0	25.0	0.412	0.447	0.564	0.559	1.44	1.44	1.24	1.16
	JKF25-2	1	1216	6	25.8	25.0	0.395	0.402	0.539	0.566	1.24	1.4	1.16	1.12
	JKF25-3	1	1221	6	26.3	26.0	0.363	0.436	0.583	0.502	1.28	1.4	1.16	1.16
plot	JKF25-4	1	1224	6	26.2	26.0	0.382	0.43	0.526	0.513	1.44	1.44	1.36	1.28
	JKF25-5	1	1230	6	25.9	25.0	0.391	0.465	0.518	0.548	1.44	1.44	1.12	1.6
Average					25.84	25.4	0.3886	0.436	0.546	0.5376	1.368	1.424	1.208	1.264
Std. Dev.					0.513	0.548	0.01798	0.02321	0.02705	0.02848				
	JKF25-6	2	1243	6	25.7	25.0	0.284	0.317	0.327	0.321	1.28	1.28	1.24	1.12
plot	JKF25-7	2	1244	6	25.7	25.0	0.281	0.298	0.333	0.318	1.72	1.36	1.28	1.2
	JKF25-8	2	1248	6	25.8	25.0	0.243	0.286	0.3	0.298	1.52	1.28	1.4	1.4
	JKF25-9	2	1251	6	25.6	25.0	0.255	0.253	0.273	0.285	1.32	1.4	1.24	1.4
	JKF25-10	2	1256	6	25.5	25.0	0.274	0.303	0.334	0.336	1.56	1.6	1.48	1.32
Average					25.66	25.0	0.2674	0.2914	0.3134	0.3116	1.48	1.384	1.328	1.288
Std. Dev.					0.114	0.0	0.0177	0.02417	0.02648	0.02011				
	JKF25-11	3		6	27.0	26.0	0.274	0.244	0.275	0.29	1.52	1.4	1.32	1.28
plot	JKF25-12	3		6	27.4	27.0	0.258	0.276	0.31	0.298	1.36	1.36	1.28	1.64
	JKF25-13	3		6	27.0	26.0	0.257	0.297	0.32	0.326	1.32	1.36	1.4	1.56
	JKF25-14	3		6	25.7	25.0	0.232	0.255	0.275	0.277	1.32	1.2	1.48	1.52
	JKF25-15	3	1340	6	26.0	25.0	0.284	0.278	0.281	0.284	1.44	1.32	1.32	1.2
Average					26.62	25.8	0.261	0.27	0.2922	0.295	1.392	1.328	1.36	1.44
Std. Dev.					0.729	0.837	0.01977	0.0208	0.02125	0.01897				
	JKF25-16	1	1420	4	27.5	27.0	0.365	0.383	0.451	0.496	1.24	1.32	1.2	1.2
	JKF25-17	1	1423	4	28.5	28.0	0.331	0.361	0.457	0.433	1.24	1.32	1.44	1.28
plot	JKF25-18	1	1426	4	28.4	28.0	0.333	0.38	0.444	0.455	1.4	1.2	1.2	1.28
	JKF25-19	1	1430	4	28.4	28.0	0.327	0.352	0.461	0.43	1.36	1.4	1.48	1.16
	JKF25-20	1	1435	4	28.7	28.0	0.299	0.347	0.478	0.445	1.44	1.72	1.4	1.48
Average					28.3	27.8	0.331	0.3646	0.4582	0.4518	1.336	1.392	1.344	1.28
Std. Dev.					0.464	0.447	0.02345	0.01626	0.01279	0.02664				
	JKF25-21	2	1440	4	28.5	28.0	0.298	0.32	0.289	0.314	1.48	1.56	1.4	1.48
	JKF25-22	2	1444	4	28.3	28.0	0.23	0.304	0.295	0.243	1.24	1.44	1.56	1.48
	JKF25-23	2	1447	4	28.2	27.0	0.294	0.276	0.271	0.299	1.4	1.24	1.48	1.24
plot	JKF25-24	2	1450	4	28.3	28.0	0.284	0.304	0.293	0.323	1.68	1.4	1.6	1.28
	JKF25-25	2	1454	4	28.2	27.0	0.298	0.285	0.308	0.352	1.52	1.36	1.28	1.48
Average					28.3	27.6	0.2808	0.2978	0.2912	0.3062	1.464	1.4	1.464	1.392
Std. Dev.					0.122	0.548	0.02897	0.01738	0.01335	0.04027				
plot	JKF25-26	3	1459	4	28.3	28.0	0.229	0.241	0.299	0.253	1.44	1.16	1.52	1.4
	JKF25-27	3	1502	4	28.1	28.0	0.224	0.246	0.231	0.255	1.24	1.64	1.16	1.36
	JKF25-28	3	1506	4	28.3	28.0	0.246	0.254	0.277	0.258	1.28	1.6	1.32	1.56
	JKF25-29	3	1510	4	28.5	28.0	0.262	0.271	0.311	0.25	1.52	1.48	1.64	1.36
	JKF25-30	3	1512	4	28.1	27.0	0.245	0.216	0.256	0.246	1.56	1.56	1.52	1.52
Average					28.6	27.8	0.2412	0.2456	0.2748	0.2524	1.408	1.488	1.432	1.44
Std. Dev.					0.167	0.447	0.01512	0.02008	0.0323	0.00462				
	JKF25-56	1	1825	3	27.0	26.0	0.24	0.297	0.368	0.365	1.6	1.36	1.44	1.32
	JKF25-57	1	1828	3	27.2	26.0	0.255	0.334	0.413	0.408	1.4	1.36	1.4	1.36
plot	JKF25-58	1	1832	3	27.0	26.0	0.268	0.325	0.396	0.368	1.36	1.36	1.24	1.72
	JKF25-59	1	1835	3	27.3	27.0	0.268	0.328	0.379	0.388	1.52	1.56	1.56	1.52

Table 6 (Continued)

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of maximum wave, sec Gage 1	Gage 2	Gage 3	Gage 4
Date: 7/25/00														
MAXPOW Tests														
	JKF25-60	1	1838	3	27.5	26.0	0.253	0.298	0.394	0.371	1.36	1.48	1.36	1.56
Average					27.2	26.2	0.2568	0.3164	0.39	0.38	1.448	1.424	1.4	1.496
Std. Dev.					0.212	0.447	0.01173	0.01756	0.01722	0.01801				
	JKF25-61	2	1835	3	27.4	27.0	0.198	0.233	0.263	0.285	1.56	1.4	1.6	1.32
	JKF25-62	2	1845	3	27.5	27.0	0.277	0.277	0.301	0.278	1.52	1.12	1.32	1.32
	JKF25-63	2	1849	3	27.5	27.0	0.24	0.263	0.285	0.266	1.4	1.6	1.24	1.36
	JKF25-64	2	1853	3	27.5	27.0	0.224	0.237	0.253	0.223	1.4	1.36	1.56	1.32
plot	JKF25-65	2	1855	3	27.5	27.0	0.241	0.256	0.266	0.281	1.24	1.4	1.52	1.36
Average					27.48	27.0	0.236	0.2532	0.2736	0.2666	1.424	1.376	1.448	1.336
Std. Dev.					0.044	0.0	0.02877	0.01831	0.0192	0.02538				
	JKF25-66	3	1901	3	27.4	27.0	0.206	0.216	0.249	0.226	1.2	1.48	1.2	1.16
plot	JKF25-67	3	1903	3	27.4	27.0	0.193	0.216	0.227	0.226	1.28	1.96	1.56	1.36
	JKF25-68	3	1906	3	27.4	27.0	0.185	0.206	0.204	0.191	1.12	1.32	1.12	1.28
	JKF25-69	3	1909	3	27.2	27.0	0.18	0.18	0.202	0.199	1.32	1.36	1.36	1.36
	JKF25-70	3	1914	3	27.4	27.0	0.169	0.197	0.19	0.205	1.4	1.28	1.44	1.16
Average					27.36	27.0	0.1866	0.203	0.2144	0.2094	1.264	1.48	1.336	1.264
Std. Dev.					0.089	0.0	0.0139	0.0151	0.02352	0.01595				
MAXWAV Tests														
Search For Maximum Wave														
	JKF25-31	2		4	12.8		0.425	0.467	0.53	0.498	1.96	1.36	1.72	1.48
	JKF25-32	2		4	10.2		0.421	0.48	0.578	0.531	1.76	1.64	1.68	1.56
	JKF25-33	2		4	9.2		0.462	0.469	0.569	0.571	1.72	1.92	1.6	1.6
	JKF25-34	2		4	8.3		0.55	0.483	0.54	0.574	1.72	1.56	1.8	1.88
	JKF25-35	2		4	7.1		0.298	0.314	0.317	0.333	1.48	1.68	1.96	0.72
	JKF25-36	2		4	14.2		0.438	0.6	0.556	0.628	1.36	1.84	1.4	1.2
	JKF25-37	2		4	15.0		0.486	0.49	0.547	0.498	1.28	1.48	1.52	1.36
	JKF25-38	2		4	15.5		0.398	0.456	0.513	0.51	1.56	1.48	1.44	1.56
Possible Maximum Wave at 14.2 mph														
	JKF25-36	***2***		***4***	***14.2***		0.438	0.6	0.556	0.628	1.36	1.84	1.4	1.2
	JKF25-39	2		4	14.0		0.377	0.458	0.498	0.426	1.64	1.92	1.44	1.4
plot	JKF25-40	2		4	13.8		0.403	0.463	0.491	0.485	1.4	1.6	1.64	1.52
	JKF25-41	2		4	14.1		0.404	0.451	0.494	0.465	1.28	1.32	1.44	1.28
	JKF25-42	2		4	14.3		0.386	0.376	0.421	0.442	1.76	1.32	1.56	1.64
Average					14.08		0.4016	0.4696	0.492	0.4892	1.488	1.6	1.496	1.408
Std. Dev.					0.192		0.02335	0.08107	0.0479	0.08076				
Possible Maximum Wave at 15.0 mph														
	JKF25-37	***2***		***4***	***15.0***		0.486	0.49	0.547	0.498	1.28	1.48	1.52	1.36
	JKF25-43	2		4	15.0		0.345	0.423	0.42	0.441	1.32	1.48	1.6	1.44
	JKF25-44	2		4	14.9		0.366	0.416	0.434	0.428	1.68	1.4	1.48	1.4
	JKF25-45	2		4	15.1		0.382	0.427	0.439	0.432	1.64	1.56	1.56	1.44
plot	JKF25-46	2		4	15.5		0.37	0.435	0.438	0.457	1.56	1.4	1.6	1.4
Average					15.1		0.3898	0.4382	0.4556	0.4512	1.496	1.464	1.552	1.408
Std. Dev.					0.235		0.05541	0.02976	0.05166	0.02844				
Maximum Wave at 9.3 mph														
	JKF25-33	***2***		***4***	***9.2***		0.462	0.469	0.569	0.571	1.72	1.92	1.6	1.6
plot	JKF25-47	2		4	9.1		0.472	0.487	0.543	0.531	1.84	1.88	1.68	1.76
	JKF25-48	2		4	9.0		0.505	0.485	0.522	0.534	1.68	1.72	1.64	1.68

Table 6 (Concluded)

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of maximum wave, sec Gage 1	Gage 2	Gage 3	Gage 4
Date: 7/25/00														
MAXWAV Tests (Continued)														
	JKF25-49	2		4	9.2		0.462	0.511	0.606	0.568	1.88	1.76	1.68	1.92
	JKF25-50	2		4	9.3		0.429	0.509	0.596	0.573	1.76	1.76	1.68	1.68
Average					9.16		0.466	0.4922	0.5672	0.5554	1.776	1.808	1.656	1.728
Std. Dev.					0.114		0.02719	0.0177	0.03524	0.02101				
	JKF25-51	3		4	9.2		0.388	0.455	0.538	0.481	2.08	1.84	1.68	1.72
	JKF25-52	3		4	9.2		0.417	0.417	0.466	0.481	1.96	1.96	1.56	1.68
	JKF25-53	3		4	9.1		0.374	0.467	0.502	0.507	1.72	1.88	1.92	2
	JKF25-54	3		4	9.1		0.382	0.4	0.438	0.436	1.88	2.16	2	1.88
plot	JKF25-55	3		4	9.3		0.365	0.407	0.465	0.459	1.84	2.04	1.96	1.92
Average					9.18		0.3852	0.4292	0.4818	0.4728	1.896	1.976	1.824	1.84
Std. Dev.					0.084		0.01977	0.02995	0.03878	0.02669				
Search for Maximum Wave														
	JKF25-71	2		3	10.2		0.352	0.443	0.515	0.519	1.8	1.6	1.96	1.76
	JKF25-72	2		3	8.0		0.483	0.542	0.579	0.686	1.72	1.6	1.6	1.48
	JKF25-73	2		3	12.0		0.377	0.427	0.466	0.45	1.88	1.48	1.52	1.64
	JKF25-74	2		3	8.9		0.439	0.487	0.547	0.528	1.6	1.56	1.52	1.44
	JKF25-75	2		3	7.5		0.342	0.378	0.435	0.426	1.76	1.72	1.64	1.56
	JKF25-76	2		3	14.1		0.384	0.404	0.467	0.403	1.56	1.4	1.44	1.32
Maximum Wave Found at 8.0 mph														
	JKF25-72	**2**		**3**	***8.0***		0.483	0.542	0.579	0.686	1.72	1.6	1.6	1.48
	JKF25-77	2		3	8.0		0.491	0.565	0.557	0.522	1.68	1.72	1.6	1.68
plot	JKF25-78	2		3	8.1		0.464	0.544	0.536	0.56	1.68	1.56	1.52	1.64
	JKF25-79	2		3	7.9		0.486	0.492	0.524	0.556	1.64	1.36	1.6	1.68
	JKF25-80	2		3	7.9		0.455	0.511	0.555	0.549	1.68	1.56	1.6	1.72
Average					7.98		0.4758	0.5308	0.5502	0.5746	1.68	1.56	1.584	1.64
Std. Dev.					0.084		0.01548	0.02901	0.02114	0.06401				
	JKF25-81	3		3	8.0		0.452	0.485	0.527	0.526	1.88	1.56	1.68	1.76
	JKF25-82	3		3	8.0		0.511	0.537	0.577	0.524	1.64	1.6	1.68	1.68
plot	JKF25-83	3		3	8.1		0.415	0.445	0.501	0.491	1.56	1.84	1.48	1.48
	JKF25-84	3		3	8.0		0.429	0.434	0.472	0.5	1.8	1.72	1.8	1.52
	JKF25-85	3		3	8.0		0.415	0.467	0.465	0.477	1.88	1.76	1.64	1.6
Average					8.02		0.4444	0.4736	0.5084	0.5036	1.752	1.696	1.656	1.608
Std. Dev.					0.048		0.04018	0.04056	0.04559	0.0212				

(Sheet 3 of 3)

Table 7
Johnson Lake Boatwake Investigations, Klamath, 35 hp, MAXPOW and MAXWAV Tests

Date: 7/26/00

MAXPOW Tests

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum wave height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of Maximum Wave, sec Gage 1	Gage 2	Gage 3	Gage 4
	JKL26-31	1	1406	3	24.2	24.0	0.445	0.465	0.553	0.518	0.84	1.2	1.36	1.44
	JKL26-32	1	1409	3	24.7	24.0	0.334	0.382	0.438	0.482	1.16	1.16	1.4	1.32
plot	JKL26-33	1	1411	3	24.7	24.0	0.382	0.426	0.482	0.49	1.28	1.36	1.4	1.04
	JKL26-34	1	1416	3	24.6	24.0	0.37	0.457	0.423	0.477	1.32	0.96	1.28	0.92
	JKL26-35	1	1420	3	24.6	24.0	0.376	0.435	0.482	0.454	1.4	0.92	1.16	1.12
Average					24.56	24.0	0.3814	0.433	0.4756	0.4842	1.2	1.12	1.32	1.168
Std. Dev.					0.207	0.0	0.04016	0.03261	0.05063	0.02316				
	JKL26-36	2	1507	3	24.1	24.0	0.334	0.371	0.409	0.382	1.44	1.36	0.96	0.6
	JKL26-37	2	1512	3	24.3	24.0	0.286	0.342	0.3	0.382	0.76	1.48	1	1.32
plot	JKL26-38	2	1515	3	24.1	24.0	0.374	0.393	0.39	0.404	1.08	1.32	1.32	1.16
	JKL26-39	2	1518	3	24.3	24.0	0.382	0.315	0.349	0.359	1.56	1.6	0.8	1.48
	JKL26-40	2	1522	3	24.2	24.0	0.38	0.404	0.384	0.414	0.96	1.44	0.76	1.44
Average					24.2	24.0	0.3512	0.365	0.3664	0.3882	1.16	1.44	0.968	1.2
Std. Dev					0.1	0.0	0.04137	0.03664	0.04299	0.02148				
	JKL26-41	3	1524	3	24.1	23.0	0.338	0.32	0.32	0.389	0.76	1	1.16	0.88
plot	JKL26-42	3	1526	3	24.0	23.0	0.329	0.321	0.342	0.319	1.4	1.08	1.32	1.44
	JKL26-43	3	1532	3	23.9	23.0	0.377	0.363	0.32	0.352	0.8	1.48	1.04	0.96
	JKL26-44	3	1535	3	24.1	23.0	0.352	0.354	0.353	0.278	1.56	0.96	1.28	1.2
	JKL26-45	3		3	24.0	23.0	0.312	0.272	0.296	0.35	1.2	1.48	1.2	1.52
Average					24.02	23.0	0.3416	0.326	0.3262	0.3376	1.144	1.2	1.2	1.2
Std. Dev.					0.084	0.0	0.02454	0.03581	0.02212	0.04154				
	JKL26-84	1	1940	4	23.3	23.0	0.399	0.526	0.697	0.619	1.24	1.28	1.28	1.12
	JKL26-85	1	1944	4	23.4	23.0	0.408	0.471	0.561	0.54	1.16	1.44	1.16	1.12
plot	JKL26-86	1	1946	4	23.4	23.0	0.388	0.473	0.538	0.576	1.28	1.24	1.48	1.32
	JKL26-87	1	1952	4	23.3	22.0	0.424	0.453	0.535	0.579	1.24	1.32	1.24	1.16
	JKL26-88	1	1954	4	23.3	23.0	0.367	0.41	0.476	0.524	1.16	1.2	1.2	1
Average					23.34	22.8	0.3972	0.4666	0.5614	0.5676	1.216	1.296	1.272	1.144
Std. Dev.					0.055	0.447	0.02142	0.04176	0.08204	0.0371				
	JKL26-89	2	1958	4	23.5	23.0	0.32	0.375	0.378	0.418	1.08	1.32	1.36	1.24
plot	JKL26-90	2	2000	4	23.4	23.0	0.35	0.367	0.379	0.396	1.2	1.44	1.12	1.12
	JKL26-91	2	2003	4	23.2	23.0	0.346	0.361	0.369	0.363	1.16	1.24	1.36	1.2
	JKL26-92	2	2005	4	23.3	23.0	0.33	0.361	0.384	0.368	1.24	1.32	1.4	1.48
	JKL26-93	2	2008	4	23.4	23.0	0.35	0.401	0.393	0.404	1.24	1.28	1.36	1.44
Average					23.36	23.0	0.3392	0.373	0.3806	0.3898	1.184	1.32	1.32	1.296
Std. Dev.					0.114	0.0	0.01354	0.01667	0.00879	0.02361				
	JKL26-94	3	2011	4	23.4		0.321	0.356	0.326	0.363	1.32	1.4	1.32	1.32
plot	JKL26-95	3	2017	4	23.2		0.301	0.309	0.334	0.32	1.48	1.36	1.4	1.24
	JKL26-96	3	2020	4	23.5	23.0	0.311	0.302	0.333	0.3	1.16	1.48	1.24	1.32
	JKL26-97	3	2023	4	23.3	23.0	0.291	0.321	0.328	0.308	1.24	1.24	1.24	1.16
	JKL26-98	3		4	23.3	23.0	0.299	0.287	0.32	0.286	1.36	1.24	1.28	1.44
Average					23.34	23.0	0.3046	0.315	0.3282	0.3154	1.312	1.344	1.296	1.296
Std. Dev.					0.114	0.0	0.01161	0.02601	0.00567	0.02934				
plot	JKL26-1	1	938	5	23.3	23.0	0.476	0.52	0.637	0.639	1.2	1.24	1.36	1.36
	JKL26-2	1	943	5	23.3	23.0	0.488	0.541	0.666	0.624	1.52	1.32	1.32	1.28
	JKL26-3	1	945	5	23.2	23.0	0.435	0.528	0.61	0.58	1.16	1.32	1.44	1.44
	JKL26-4	1	948	5	23.2	23.0	0.485	0.501	0.626	0.595	1.52	1.08	1.4	1.2

Table 7 (Continued)

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum wave height, ft				Period of Maximum Wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
Date: 7/26/00														
MAXPOW Tests														
	JKL26-5	1	1001	5	23.3	23.0	0.452	0.518	0.64	0.644	1.4	1.48	1.28	1.24
Average					23.26	23.0	0.4672	0.5216	0.6358	0.6164	1.36	1.288	1.36	1.304
Std. Dev.					0.055	0.0	0.02288	0.01464	0.02057	0.0279				
	JKL26-6	2	1003	5	23.3	23.0	0.389	0.429	0.465	0.439	1.28	1.52	1.44	1.08
	JKL26-7	2	1006	5	23.2	23.0	0.395	0.417	0.423	0.422	1.2	1.2	1.2	1.4
	JKL26-8	2	1009	5	23.2	23.0	0.364	0.396	0.419	0.431	1.24	1.08	1.08	1.44
plot	JKL26-9	2	1011	5	23.0	22.0	0.367	0.402	0.424	0.439	1.4	1.28	1.24	1.32
	JKL26-10	2	1015	5	23.0	22.0	0.381	0.399	0.395	0.392	1.36	1.12	1	1.24
Average					23.14	22.6	0.3792	0.4086	0.4252	0.4246	1.296	1.24	1.192	1.296
Std. Dev.					0.134	0.548	0.0135	0.01397	0.0252	0.01953				
	JKL26-11	3	1019	5	23.3	23.0	0.335	0.38	0.361	0.414	1.32	1.4	1.32	1.28
	JKL26-12	3	1023	5	23.1	22.0	0.335	0.338	0.362	0.416	1.2	1.4	1.44	1.4
	JKL26-13	3		5	23.2	23.0	0.317	0.318	0.339	0.334	1.28	1.28	1.12	1.28
plot	JKL26-14	3		5	23.2	23.0	0.346	0.338	0.335	0.361	1.32	1.32	1.36	1.24
	JKL26-15	3		5	23.2	23.0	0.371	0.356	0.336	0.385	1.16	1.24	1.16	1.32
Average					23.2	22.8	0.3408	0.346	0.3466	0.382	1.256	1.328	1.28	1.304
Std. Dev.					0.07	0.447	0.01983	0.02328	0.01369	0.03512				
MAXWAV Tests														
Search for Maximum Wave														
	JKL26-46	2		3	11.0		0.462	0.51	0.545	0.481	1.2	1.44	1.52	1.24
	JKL26-47	2		3	7.8		0.54	0.512	0.642	0.635	1.2	1.08	1.44	1.44
	JKL26-48	2		3	9.5		0.447	0.486	0.6	0.542	1.64	1.56	1.56	1.84
	JKL26-49	2		3	7.4		0.491	0.575	0.563	0.522	1.32	1.24	1.48	1.28
	JKL26-50	2		3	8.4		0.586	0.621	0.681	0.668	1.72	1.4	1.8	1.76
Possible Maximum Wave At 8.4 mph														
	JKL26-50	***2***		***3***	***8.4***		0.586	0.621	0.681	0.668	1.72	1.4	1.8	1.76
	JKL26-51	2		3	8.7		0.606	0.532	0.579	0.646	1.68	1.68	1.6	1.76
	JKL26-52	2		3	8.5		0.469	0.421	0.5	0.518	1.52	1.8	1.8	1.48
plot	JKL26-53	2		3	8.6		0.518	0.566	0.63	0.603	1.08	1.52	1.6	1.84
	JKL26-54	2		3	8.5		0.549	0.52	0.54	0.475	1.64	1.72	1.72	1.64
Average					8.54		0.5456	0.532	0.586	0.582	1.528	1.624	1.704	1.696
Std. Dev.					0.114		0.05459	0.07339	0.07163	0.08288				
	JKL26-55	3		3	8.3		0.454	0.44	0.595	0.483	1.72	1.4	1.72	1.56
	JKL26-56	3		3	8.5		0.45	0.469	0.53	0.628	1.4	1.44	1.56	1.48
	JKL26-57	3		3	8.7		0.617	0.616	0.668	0.615	1.64	1.36	1.56	1.56
	JKL26-58	3		3	8.3		0.452	0.526	0.483	0.54	1.64	1.96	1.4	1.64
plot	JKL26-59	3		3	8.2		0.502	0.495	0.562	0.543	1.64	1.8	1.76	1.56
Average					8.4		0.495	0.5092	0.5676	0.5618	1.608	1.592	1.6	1.56
Std. Dev.					0.2		0.07157	0.06763	0.0697	0.05969				
Possible Maximum Wave At 7.8 mph														
	JKL26-47	***2***		***3***	***7.8***		0.54	0.512	0.642	0.635	1.2	1.08	1.44	1.44
	JKL26-60	2		3	7.8		0.507	0.604	0.641	0.678	1.52	1.6	1.44	1.6
	JKL26-61	2		3	7.8		0.612	0.677	0.597	0.574	1.64	1.6	1.36	1.08
	JKL26-62	2		3	7.7		0.481	0.658	0.58	0.532	1.68	1.56	1.52	1.68
plot	JKL26-63	2		3	7.7		0.585	0.566	0.607	0.577	1.44	1.32	1.2	1.56
Average					7.76		0.545	0.6034	0.6134	0.5992	1.496	1.432	1.392	1.472
Std. Dev.					0.055		0.05398	0.06736	0.02741	0.0573				

(Sheet 2 of 4)

Table 7 (Continued)

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum wave height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of Maximum Wave, sec Gage 1	Gage 2	Gage 3	Gage 4
Date: 7/26/00														
MAXWAV Tests (Continued)														
	JKL26-64	3		3	7.6		0.476	0.579	0.673	0.532	1.64	1.6	1.56	1.2
	JKL26-65	3		3	7.8		0.459	0.525	0.48	0.506	1.32	1.48	1.48	1.76
plot	JKL26-66	3		3	7.8		0.505	0.589	0.592	0.628	1.44	1.4	1.56	1.36
	JKL26-67	3		3	7.7		0.447	0.473	0.576	0.7	1.48	1.44	1.72	1.4
	JKL26-68	3		3	7.7		0.61	0.608	0.621	0.692	1.48	1.76	1.56	1.52
Average					7.72		0.4994	0.5548	0.5884	0.6116	1.472	1.536	1.576	1.448
Std. Dev.					0.084		0.06555	0.05515	0.07095	0.08949				
Search for Maximum Wave														
	JKL26-69	2		4	7.7		0.558	0.532	0.557	0.588	1.84	1.68	1.84	1.64
	JKL26-70	2		4	8.9		0.507	0.627	0.743	0.694	1.52	1.48	1.68	1.76
	JKL26-71	2		4	7.3		0.584	0.593	0.627	0.602	1.6	1.36	1.48	1.44
	JKL26-72	2		4	7.9		0.763	0.796	0.743	0.807	1.4	1.52	1.52	1.52
	JKL26-73	2		4	7.6		0.523	0.472	0.545	0.699	1.68	1.48	1.76	1.36
	JKL26-74	2		4	10.0		0.509	0.601	0.637	0.628	1.52	1.6	1.28	1.44
Maximum Wave Found at 8.0 mph														
	JKL26-72	***2***		***4***	***7.9***		0.763	0.796	0.743	0.807	1.4	1.52	1.52	1.52
	JKL26-75	2		4	8.2		0.757	0.665	0.775	0.67	1.44	1.48	1.4	1.32
	JKL26-76	2		4	8.2		0.496	0.586	0.664	0.642	1.52	1.4	1.56	1.56
	JKL26-77	2		4	8.3		0.573	0.602	0.59	0.542	1.8	1.4	1.28	1.44
plot	JKL26-78	2		4	8.4		0.578	0.639	0.738	0.736	1.28	1.76	1.52	1.44
Average					8.2		0.6334	0.6576	0.702	0.6794	1.488	1.512	1.456	1.456
Std. Dev.					0.187		0.12007	0.08333	0.07466	0.09981				
	JKL26-79	3		4	7.8		0.532	0.492	0.473	0.494	1.56	1.32	2.04	1.52
	JKL26-80	3		4	8.3		0.631	0.642	0.645	0.551	1.6	1.52	1.52	1.6
	JKL26-81	3		4	8.8		0.527	0.615	0.694	0.546	1.4	1.6	1.56	1.6
plot	JKL26-82	3		4	8.5		0.589	0.602	0.639	0.556	1.56	1.84	1.52	1.52
	JKL26-83	3		4	8.1		0.544	0.572	0.666	0.616	1.56	1.64	1.48	1.48
Average					8.3		0.5646	0.5846	0.6234	0.5526	1.536	1.584	1.624	1.544
Std. Dev.					0.381		0.04446	0.05757	0.08679	0.04333				
Search for Maximum Wave														
	JKL26-16	2		5	9.5		0.51	0.603	0.731	0.69	1.44	1.6	1.64	1.6
	JKL26-17	2		5	8.0		0.53	0.698	0.797	0.726	1.32	1.48	1.4	1.24
	JKL26-18	2		5	7.2		0.527	0.607	0.54	0.508	1.52	1.44	1.8	1.64
	JKL26-19	2		5	8.2		0.615	0.843	0.72	0.771	1.44	1.52	1.16	1.28
	JKL26-20	2		5	8.9		0.647	0.699	0.758	0.709	1.56	1.48	1.68	1.72
	JKL26-21	2		5	11.5		0.456	0.54	0.526	0.542	1.68	1.44	1.52	1.08
Maximum Wave Found at 8.2														
	JKL26-19	***2***		***5***	***8.2***		0.615	0.843	0.72	0.771	1.44	1.52	1.16	1.28
	JKL26-22	2		5	8.6		0.6	0.643	0.708	0.637	1.56	1.72	1.52	1.44
	JKL26-23	2		5	8.2		0.671	0.629	0.686	0.752	1.64	1.72	1.52	1.68
	JKL26-24	2		5	8.4		0.591	0.613	0.766	0.753	1.56	1.68	1.4	1.44
plot	JKL26-25	2		5	8.6		0.585	0.646	0.756	0.72	1.76	1.48	1.24	1.52
Average					8.4		0.6124	0.6748	0.7272	0.7266	1.592	1.624	1.368	1.472
Std. Dev.					0.2		0.03465	0.09493	0.03336	0.05335				
plot	JKL26-26	3		5	8.4		0.554	0.697	0.625	0.658	1.84	1.52	1.44	1.64
	JKL26-27	3		5	8.4		0.733	0.699	0.664	0.652	1.72	1.36	1.76	1.4

(Sheet 3 of 4)

Table 7 (Concluded)

Date: 7/26/00														
MAXWAV Tests														
					Speed	Speed	Maximum wave height, ft				Period of Maximum Wave, sec			
	Test No.	Sail	Time	Load	GPS mph	Radar mph	Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	JKL26-28	3		5	8.3		0.554	0.614	0.654	0.554	1.8	1.6	1.76	1.76
	JKL26-29	3		5	8.5		0.522	0.562	0.671	0.642	1.6	1.16	1.44	1.44
	JKL26-30	3		5	8.3		0.566	0.535	0.575	0.648	1.76	1.96	1.48	1.8
Average					8.38		0.5858	0.6214	0.6378	0.6308	1.744	1.52	1.576	1.608
Std. Dev.					0.084		0.08389	0.07547	0.03924	0.04333				

(Sheet 4 of 4)

Table 8
Johnson Lake Boatwake Investigations, Klamath, 40 hp, MAXPOW Tests

Date: 7/27/00														
MAXPOW Tests														
					Speed	Speed	Maximum Wave Height, ft				Period of Maximum Wave, sec			
	Test No.	Sail	Time	Load	GPS mph	Radar mph	Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	JKL27-1	1	1728	5	22.1	21.0	0.479	0.537	0.616	0.644	1.12	1.48	1.4	1.44
	JKL27-2	1	1732	5	25.1	24.0	0.412	0.488	0.537	0.558	1.2	0.84	1.24	0.96
	JKL27-3	1	1734	5	24.7	24.0	0.407	0.459	0.535	0.589	1.24	1.68	1.28	1.28
plot	JKL27-4	1	1736	5	24.3	23.0	0.437	0.475	0.552	0.616	1.2	1.32	0.92	1.16
	JKL27-5	1	1739	5	25.1	24.0	0.426	0.479	0.629	0.569	1.32	1.28	1.48	1.08
Average					24.26	23.2	0.4322	0.4876	0.5738	0.5952	1.216	1.32	1.264	1.184
Std. Dev.					1.252	1.304	0.0287	0.02954	0.04517	0.03508				
	JKL27-6	2	1742	5	24.6	24.0	0.32	0.332	0.367	0.378	1.36	1.28	1.2	1.44
	JKL27-7	2	1744	5	24.6	24.0	0.356	0.331	0.414	0.396	1.08	1.28	1.16	1.16
	JKL27-8	2	1746	5	24.9	24.0	0.33	0.406	0.382	0.393	1.44	1.48	1.36	1.4
plot	JKL27-9	2	1749	5	24.9	24.0	0.315	0.379	0.389	0.394	1	1.4	1.4	1.56
	JKL27-10	2	1751	5	25.3	25.0	0.312	0.341	0.383	0.358	1.36	1.16	1.32	1.24
Average					24.86	24.2	0.3266	0.3578	0.387	0.3838	1.248	1.32	1.288	1.36
Std. Dev.					0.288	0.447	0.0178	0.03331	0.01713	0.0161				
	JKL27-11	3	1754	5	24.4	24.0	0.291	0.296	0.397	0.37	1.36	1.44	1.32	1.48
plot	JKL27-12	3	1757	5	24.7	24.0	0.316	0.333	0.388	0.381	1.36	1.4	1.16	1.4
	JKL27-13	3	1800	5	24.8	24.0	0.364	0.364	0.34	0.343	1.48	0.84	1.24	1.32
	JKL27-14	3	1002	5	25.1	24.0	0.297	0.313	0.351	0.319	1.12	1.16	1.28	1.32
	JKL27-15	3	1805	5	25.0	24.0	0.281	0.305	0.299	0.339	1.36	1.32	1.48	1.36
Average					24.8	24.0	0.3098	0.3222	0.355	0.3504	1.336	1.232	1.296	1.376
Std. Dev.					0.274	0.0	0.03287	0.02707	0.03947	0.02496				
plot	JKL27-16	1	1816	4	24.9	24.0	0.345	0.399	0.502	0.491	1.32	1.48	1.12	1.04
	JKL27-17	1	1818	4	25.3	25.0	0.321	0.362	0.511	0.468	1.12	1.64	1.4	1.48
	JKL27-18	1	1821	4	24.2	23.0	0.326	0.445	0.502	0.476	1.28	1.08	1.32	1.04
	JKL27-19	1	1823	4	24.7	24.0	0.366	0.452	0.539	0.498	1.28	1.36	1.4	1.2
	JKL27-20	1	1826	4	25.1	24.0	0.351	0.468	0.55	0.555	1.12	0.96	1.2	1.04
Average					24.84	24.0	0.3418	0.4252	0.5208	0.4976	1.224	1.304	1.288	1.16
Std.Dev.					0.422	0.707	0.01846	0.04365	0.02229	0.03421				
	JKL27-21	2	1829	4	25.0	25.0	0.291	0.291	0.316	0.388	1.16	1.48	1.04	1.28
	JKL27-22	2	1831	4	25.2	25.0	0.3	0.338	0.357	0.377	1.28	1.12	1.44	1.32
plot	JKL27-23	2	1833	4	24.7	24.0	0.304	0.304	0.346	0.365	1.32	1.4	1.52	1.16
	JKL27-24	2	1835	4	25.6	25.0	0.295	0.319	0.381	0.363	1.36	1.28	1.36	1.4
	JKL27-25	2	1840	4	23.8	23.0	0.312	0.342	0.348	0.355	1.32	1.64	1.2	1.4
Average					24.86	24.4	0.3004	0.3188	0.3496	0.3696	1.288	1.384	1.312	1.312
Std. Dev.					0.677	0.894	0.00814	0.02179	0.02337	0.01295				
plot	JKL27-26	3	1844	4	25.3	24.0	0.251	0.257	0.284	0.277	1.36	1.36	1.76	1.32
	JKL27-27	3	1848	4	25.1	24.0	0.217	0.243	0.237	0.261	1.68	1.6	1.48	1.32
	JKL27-28	3	1850	4	25.1	24.0	0.226	0.252	0.289	0.276	1.36	1.44	0.96	1.28
	JKL27-29	3	1852	4	24.2	24.0	0.277	0.289	0.331	0.279	1.32	1.32	1.4	1.2
	JKL27-30	3	1854	4	25.1	24.0	0.301	0.298	0.307	0.325	1.2	1.32	1.16	1.44
Average					24.96	24.0	0.2544	0.2678	0.2896	0.2836	1.384	1.408	1.352	1.312
Std. Dev.					0.434	0.0	0.035	0.0242	0.0347	0.02422				
	JKL27-31	1	1907	3	25.3	25.0	0.347	0.378	0.484	0.497	1.2	1.32	1.32	1.04
	JKL27-32	1	1909	3	25.7	25.0	0.31	0.381	0.439	0.398	1.32	1.12	1.24	1.32
plot	JKL27-33	1	1911	3	26.6	25.0	0.358	0.4	0.467	0.455	1.2	1.36	1.04	1.16

(Continued)

Table 8 (Continued)

Date: 7/27/00

MAXPOW Tests

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of Maximum Wave, sec Gage 1	Gage 2	Gage 3	Gage 4
	JKL27-34	1	1913	3	25.4	25.0	0.37	0.487	0.599	0.555	1.08	1.36	1.32	1.16
	JKL27-35	1	1916	3	25.2	25.0	0.334	0.382	0.441	0.435	1.2	1.32	1.16	1.36
Average					25.64	25.0	0.3438	0.4056	0.486	0.468	1.2	1.296	1.216	1.208
Std. Dev.					0.568	0.0	0.02311	0.04632	0.06589	0.06035				
	JKL27-36	2	1924	3	25.8	25.0	0.291	0.282	0.31	0.334	1.28	0.96	1.4	0.8
	JKL27-37	2	1927	3	25.6	25.0	0.23	0.255	0.286	0.312	1.24	1.2	1.16	1.4
	JKL27-38	2	1929	3	25.7	25.0	0.257	0.254	0.273	0.294	1.32	1.24	1.32	1.28
plot	JKL27-39	2	1932	3	24.5	24.0	0.262	0.274	0.278	0.292	1.32	1.12	1.2	1.28
	JKL27-40	2	1934	3	25.9	25.0	0.25	0.302	0.286	0.256	1.2	1.2	1.48	1.04
Average					25.5	24.8	0.258	0.2734	0.2866	0.2976	1.272	1.144	1.312	1.16
Std. Dev.					0.57	0.447	0.0221	0.02004	0.01421	0.02875				
	JKL27-41	3	1939	3	25.7	25.0	0.23	0.247	0.253	0.261	1.32	1.36	1.2	1.2
	JKL27-42	3	1941	3	25.8	25.0	0.218	0.22	0.222	0.267	1.08	1.36	1.44	1.12
plot	JKL27-43	3	1943	3	25.3	25.0	0.203	0.222	0.231	0.252	1.2	1.24	1.4	1.08
	JKL27-44	3	1945	3	25.8	25.0	0.205	0.206	0.233	0.263	1.4	1.48	1.12	1.24
	JKL27-45	3	1947	3	25.6	25.0	0.229	0.208	0.238	0.248	1.24	1.08	1.32	1.48
Average					25.64	25.0	0.217	0.2206	0.2354	0.2582	1.248	1.304	1.296	1.224
Std. Dev.					0.207	0.0	0.01279	0.01636	0.01141	0.00792				

Table 9
Johnson Lake Boatwake Investigations, Lowe, 35 hp, MAXPOW and MAXWAV Tests

Date: 7/28/00-7/29/00

MAXPOW Tests

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum wave height, ft				Period of maximum wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
plot	JLW28-46	1	1852	3	25.6	25.0	0.228	0.272	0.306	0.317	1.28	1.28	0.96	0.92
	JLW28-47	1	1854	3	25.7	24.0	0.219	0.261	0.298	0.333	1.16	1.44	1.28	1.4
	JLW28-48	1	1905	3	25.7	25.0	0.22	0.248	0.309	0.298	0.96	1.2	1.72	1.32
	JLW28-49	1	1907	3	25.5	25.0	0.202	0.244	0.34	0.278	1.16	1.2	1.48	1.16
	JLW28-50	1	1909	3	25.5	25.0	0.226	0.269	0.358	0.317	1.4	1.32	1.4	1.16
Average					25.6	24.8	0.219	0.2588	0.3222	0.3086	1.192	1.288	1.368	1.192
Std. Dev.					0.1	0.447	0.01025	0.01244	0.0256	0.02113				
	JLW28-51	2	1912	3	25.6	24.0	0.173	0.194	0.191	0.264	1.48	1.36	1.04	1.32
	JLW28-52	2	1914	3	25.0	24.0	0.152	0.167	0.212	0.229	1.2	1.48	1.28	1.28
plot	JLW28-53	2	1916	3	25.0	25.0	0.168	0.192	0.216	0.219	1.28	1.48	1.36	1.44
	JLW28-54	2	1920	3	25.0	25.0	0.171	0.181	0.205	0.235	1	1.4	1.4	1.16
	JLW28-55	2	1922	3	25.5	25.0	0.167	0.209	0.235	0.207	1.24	1.36	1.2	1.48
Average					25.22	24.6	0.1662	0.1886	0.2118	0.2308	1.24	1.416	1.256	1.336
Std. Dev.					0.303	0.548	0.00829	0.01566	0.01608	0.02138				
	JLW28-56	3	1927	3	25.9	25.0	0.16	0.182	0.189	0.184	1.36	1.52	1.24	1.52
	JLW28-57	3	1929	3	25.6	24.0	0.167	0.19	0.19	0.185	1.4	0.76	1.28	1.48
plot	JLW28-58	3	1932	3	25.5	25.0	0.171	0.17	0.181	0.18	1.28	1.48	1.44	1.32
	JLW28-59	3	1934	3	25.4	25.0	0.148	0.159	0.212	0.2	1.24	1.48	1.48	1.32
	JLW28-60	3	1936	3	25.6	25.0	0.146	0.155	0.174	0.213	1.24	1.36	1.56	1.28
Average					25.6	24.8	0.1584	0.1712	0.1892	0.1924	1.304	1.32	1.4	1.384
Std. Dev.					0.187	0.447	0.01115	0.01486	0.01431	0.01379				
	JLW29-38	1	1110	4	25.3	25.0	0.286	0.302	0.382	0.39	1.16	1.2	1.12	1.36
plot	JLW29-39	1	1112	4	25.3	24.0	0.295	0.33	0.376	0.402	1.16	1.28	1.4	1.08
	JLW29-40	1	1114	4	25.4	24.0	0.284	0.338	0.411	0.385	1.08	1.28	1.2	1.28
	JLW29-41	1	1117	4	25.7	25.0	0.283	0.333	0.424	0.429	1.04	1	1.28	1.28
	JLW29-42	1	1119	4	25.5	25.0	0.262	0.322	0.36	0.375	1.08	1.16	1.44	1.16
Average					25.44	24.6	0.282	0.325	0.3906	0.3962	1.104	1.184	1.288	1.232
Std.Dev.					0.167	0.548	0.01214	0.01411	0.02624	0.02075				
plot	JLW29-43	2	1123	4	25.7	25.0	0.22	0.219	0.25	0.248	1.32	1.52	1.32	1
	JLW29-44	2	1126	4	25.7	25.0	0.223	0.258	0.245	0.257	1.32	1.36	1.44	1.24
	JLW29-45	2	1128	4	25.6	25.0	0.215	0.258	0.244	0.283	1.52	1.4	0.8	1.6
	JLW29-46	2	1130	4	25.6	25.0	0.229	0.219	0.248	0.257	1	1.32	1.28	1.4
	JLW29-47	2	1132	4	25.6	25.0	0.21	0.256	0.261	0.291	1.32	1.48	1.6	1.28
Average					25.64	25.0	0.2194	0.242	0.2496	0.2672	1.296	1.416	1.288	1.304
Std. Dev.					0.055	0.0	0.0073	0.02101	0.0068	0.01866				
	JLW29-48	3	1137	4	25.5	25.0	0.201	0.198	0.207	0.243	1.48	1.44	1.44	1.4
plot	JLW29-49	3	1139	4	25.5	25.0	0.201	0.211	0.204	0.202	1.24	1.32	1.36	1.28
	JLW29-50	3	1141	4	25.3	25.0	0.185	0.212	0.215	0.229	1.32	1.28	1.24	1.36
	JLW29-51	3	1144	4	25.3	25.0	0.196	0.196	0.215	0.22	1.24	1.32	1.12	1.2
	JLW29-52	3	1149	4	25.3		0.183	0.189	0.193	0.234	1.32	1.28	1.16	1.24
Average					25.38	25.0	0.1932	0.2012	0.2068	0.2256	1.32	1.328	1.264	1.296
Std. Dev.					0.11	0.0	0.00867	0.00998	0.00912	0.0156				
	JLW29-71	1	1419	5	24.1	24.0	0.303	0.376	0.416	0.443	1.24	1.24	1.12	1.12
	JLW29-72	1	1423	5	24.4	24.0	0.277	0.3	0.451	0.498	1.24	1.32	1.16	1.16
	JLW29-73	1	1425	5	24.3	23.0	0.302	0.337	0.437	0.415	1.2	1.28	1.12	1.04
	JLW29-74	1	1429	5	24.4	24.0	0.312	0.372	0.437	0.461	1.2	1.12	1.24	1.12
plot	JLW29-75	1	1432	5	24.5	24.0	0.304	0.352	0.426	0.441	1.12	1.12	1.08	1.12

Table 9 (Continued)

Date: 7/28/00-7/29/00

MAXPOW Tests

					Speed	Speed	Maximum wave height, ft				Period of maximum wave, sec			
	Test No.	Sail	Time	Load	GPS mph	Radar mph	Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
Average					24.34	23.8	0.2996	0.3474	0.4334	0.4516	1.2	1.216	1.144	1.112
Std. Dev.					0.152	0.447	0.01324	0.03082	0.01316	0.03069				
	JLW29-76	2	1435	5	24.3	24.0	0.221	0.262	0.252	0.302	1.16	1.32	1.08	1.16
	JLW29-77	2	1437	5	24.7	24.0	0.239	0.246	0.263	0.286	1.36	1.28	1.36	1.28
	JLW29-78	2	1439	5	24.5	24.0	0.269	0.293	0.294	0.279	1.16	1.2	1.2	1.28
plot	JLW29-79	2	1442	5	24.2	24.0	0.237	0.262	0.29	0.28	1.24	1.32	1.16	1.2
	JLW29-80	2	1444	5	24.4	24.0	0.248	0.26	0.278	0.299	1.24	1.32	1.08	1.28
Average					24.42	24.0	0.2428	0.2646	0.2754	0.2892	1.232	1.288	1.176	1.24
Std. Dev.					0.193	0.0	0.01758	0.01723	0.0178	0.01071				
	JLW29-81	3	1450	5	24.2	24.0	0.188	0.21	0.215	0.238	1.2	1.08	1.2	1.28
plot	JLW29-82	3	1452	5	24.3	24.0	0.19	0.212	0.225	0.235	1.36	1.12	1.24	1.24
	JLW29-83	3	1454	5	24.6	24.0	0.21	0.227	0.229	0.238	1.16	1.2	1.16	1.16
	JLW29-84	3	1457	5	24.3	24.0	0.217	0.224	0.215	0.22	1.32	1.32	1.24	1.2
	JLW29-85	3	1507	5	23.9	23.0	0.207	0.234	0.25	0.228	1.2	1.2	1.24	1.28
Average					24.26	23.8	0.2024	0.2214	0.2268	0.2318	1.248	1.184	1.216	1.232
Std. Dev.					0.251	0.447	0.01278	0.01019	0.01436	0.00776				
MAXWAV Tests														
Search for Maximum Wave														
	JLW29-53	2		5	8.0		0.502	0.561	0.588	0.715	1.64	1.52	1.6	1.48
	JLW29-54	2		5	9.9		0.586	0.631	0.661	0.619	1.4	1.44	1.68	1.68
	JLW29-55	2		5	8.9		0.469	0.534	0.654	0.665	1.64	1.6	1.56	1.48
	JLW29-56	2		5	8.5		0.614	0.626	0.717	0.739	1.56	1.52	1.56	1.56
Maximum Wave Found at 8.5 mph														
	JLW29-56	***2***		***5***	***8.5***		0.614	0.626	0.717	0.739	1.56	1.52	1.56	1.56
	JLW29-57	2		5	8.4		0.579	0.638	0.677	0.69	1.64	1.52	1.64	1.6
	JLW29-58	2		5	8.5		0.479	0.564	0.671	0.685	1.6	1.6	1.6	1.6
	JLW29-59	2		5	8.5		0.518	0.548	0.63	0.758	1.56	1.68	1.56	1.56
plot	JLW29-60	2		5	8.5		0.595	0.6	0.672	0.688	1.52	1.64	1.52	1.6
Average					8.48		0.557	0.5952	0.6734	0.712	1.576	1.592	1.576	1.584
Std. Dev.					0.045		0.05653	0.03875	0.03084	0.03404				
	JLW29-61	1		5	8.5		0.755	0.819	0.903	0.925	1.6	1.4	1.44	1.44
	JLW29-62	1		5	8.4		0.674	0.861	0.816	0.818	1.68	1.44	1.48	1.56
	JLW29-63	1		5	8.6		0.698	0.767	0.812	0.878	1.6	1.44	1.52	1.56
plot	JLW29-64	1		5	8.3		0.723	0.808	0.862	0.921	1.6	1.44	1.48	1.52
	JLW29-65	1		5	8.3		0.697	0.773	0.799	0.857	1.52	1.52	1.6	1.52
Average					8.4		0.7094	0.8056	0.8384	0.8798	1.6	1.448	1.504	1.52
Std. Dev.					0.13		0.03083	0.0381	0.04325	0.04495				
	JLW29-66	3		5	8.5		0.441	0.43	0.522	0.556	1.36	1.84	1.72	1.6
	JLW29-67	3		5	8.3		0.497	0.555	0.652	0.642	1.72	1.44	1.56	1.48
plot	JLW29-68	3		5	8.5		0.483	0.546	0.572	0.525	1.76	1.76	1.68	1.56
	JLW29-69	3		5	8.5		0.501	0.544	0.555	0.489	1.68	1.64	1.68	1.76
	JLW29-70	3		5	8.5		0.596	0.643	0.731	0.68	1.52	1.68	1.56	1.44
Average					8.46		0.5036	0.5436	0.6064	0.5784	1.608	1.672	1.64	1.568
Std.Dev.					0.09		0.05686	0.0757	0.08449	0.08018				
Search for Maximum Wave														
	JLW29-23	2		4	7.8		0.507	0.592	0.694	0.73	1.4	1.44	1.48	1.44
	JLW29-24	2		4	9.2		0.54	0.603	0.646	0.679	1.52	1.52	1.44	1.32

(Sheet 2 of 4)

Table 9 (Continued)

Date: 7/28/00-7/29/00														
MAXWAV Tests (Continued)														
	Test No.	**Sail**	**Time**	**Load**	**Speed GPS mph**	**Speed Radar mph**	**Maximum wave height, ft**				**Period of maximum wave, sec**			
							Gage 1	**Gage 2**	**Gage 3**	**Gage 4**	**Gage 1**	**Gage 2**	**Gage 3**	**Gage 4**
	JLW29-25	2		4	8.5		0.63	0.656	0.75	0.744	1.44	1.48	1.52	1.52
	JLW29-26	2		4	7.3		0.55	0.573	0.567	0.561	1.4	1.36	1.4	1.4
	JLW29-27	2		4	10.0		0.562	0.572	0.614	0.638	1.36	1.44	1.56	1.6
	JLW29-28	2		4	8.1		0.712	0.83	0.801	0.826	1.28	1.36	1.36	1.48
Maximum Wave Found at 8.1 mph														
	JLW29-28	***2***		***4***	***8.1***		0.712	0.83	0.801	0.826	1.28	1.36	1.36	1.48
	JLW29-29	2		4	8.1		0.587	0.67	0.64	0.591	1.52	1.56	1.52	1.48
plot	JLW29-30	2		4	8.3		0.645	0.685	0.703	0.739	1.52	1.44	1.68	1.6
	JLW29-31	2		4	7.9		0.427	0.493	0.608	0.72	1.8	1.88	1.48	1.48
	JLW29-32	2		4	8.1		0.646	0.727	0.636	0.659	1.4	1.48	1.64	1.64
Average					8.1		0.6034	0.681	0.6776	0.707	1.504	1.544	1.536	1.536
Std. Dev.							0.10808	0.12227	0.07724	0.0882				
	JLW29-33	3		4	8.1		0.634	0.586	0.62	0.609	1.44	1.4	1.56	1.52
	JLW29-34	3		4	7.8		0.603	0.581	0.64	0.521	1.4	1.44	1.52	1.56
plot	JLW29-35	3		4	8.2		0.446	0.488	0.547	0.559	1.64	1.52	1.56	1.6
	JLW29-36	3		4	8.0		0.415	0.483	0.545	0.593	1.68	1.64	1.64	1.52
	JLW29-37	3		4	8.2		0.437	0.443	0.46	0.444	1.48	1.72	1.72	1.72
Average					8.06		0.507	0.5162	0.5624	0.5452	1.528	1.544	1.6	1.584
Std. Dev.					0.167		0.10299	0.06389	0.07135	0.0659				
Search for Maximum Wave														
	JLW29-1	2		3	9.2		0.412	0.426	0.466	0.44	1.4	1.52	1.52	1.28
	JLW29-2	2		3	7.5		0.524	0.532	0.559	0.577	1.6	1.36	1.56	1.48
	JLW29-3	2		3	8.7		0.442	0.463	0.515	0.512	1.64	1.72	1.68	1.68
	JLW29-4	2		3	7.0		0.404	0.421	0.435	0.436	1.6	1.36	1.6	1.64
	JLW29-5	2		3	8.2		0.465	0.586	0.708	0.596	1.36	1.6	1.44	1.28
Maximum Wave Found at 8.2 mph														
	JLW29-5	***2***		***3***	***8.2***		0.465	0.586	0.708	0.596	1.36	1.6	1.44	1.28
	JLW29-6	2		3	8.4		0.369	0.372	0.465	0.55	1.6	1.64	1.4	1.52
	JLW29-7	2		3	7.8		0.528	0.596	0.65	0.714	1.4	1.4	1.4	1.44
	JLW29-8	2		3	7.9									
	JLW29-9	2		3	8.0		0.57	0.554	0.655	0.57	1.6	1.48	1.56	1.52
plot	JLW29-10	2		3	7.9		0.531	0.575	0.601	0.609	1.64	1.6	1.64	1.52
	JLW29-11	2		3	8.2		0.496	0.537	0.592	0.564	1.48	1.6	1.44	1.48
Average					8.057		0.49317	0.53667	0.61183	0.6005	1.51333	1.55333	1.48	1.46
Std. Dev.					0.215		0.07038	0.08347	0.08323	0.05964				
	JLW29-12	1		3	7.8		0.741	0.716	0.738	0.712	1.48	1.64	1.32	1.28
	JLW29-13	1		3	7.4		0.657	0.697	0.749	0.631	1.36	1.4	1.28	1.2
	JLW29-14	1		3	8.0		0.54	0.667	0.687	0.743	1.64	1.44	1.32	1.28
	JLW29-15	1		3	7.8		0.562	0.54	0.712	0.728	1.48	1.36	1.4	1.36
	JLW29-16	1		3	7.9		0.763	0.778	0.636	0.756	1.4	1.44	1.44	1.6
plot	JLW29-17	1		3	7.8		0.665	0.754	0.718	0.759	1.4	1.44	1.6	1.56
Average					7.783		0.65467	0.692	0.70667	0.7215	1.46	1.45333	1.39333	1.38
Std. Dev.					0.024		0.0906	0.08434	0.04077	0.04771				
	JLW29-18	3		3	7.6		0.326	0.38	0.432	0.453	1.32	1.64	1.48	1.4
	JLW29-19	3		3	8.0		0.344	0.354	0.417	0.468	1.48	1.8	1.56	1.72
	JLW29-20	3		3	8.2		0.408	0.497	0.478	0.472	1.4	1.52	1.48	1.68

(Sheet 3 of 4)

Table 9 (Concluded)

Date: 7/28/00-7/29/00

MAXWAV Tests (Continued)

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum wave height, ft				Period of maximum wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
plot	JLW29-21	3		3	7.9		0.383	0.405	0.474	0.559	1.48	1.48	1.64	1.6
	JLW29-22	3		3	8.0		0.495	0.563	0.57	0.562	1.32	1.52	1.52	1.48
Average					7.94		0.3912	0.4398	0.4742	0.5028	1.4	1.592	1.536	1.576
Std. Dev.					0.219		0.06634	0.08746	0.05968	0.04755				

(Sheet 4 of 4)

Table 10
Johnson Lake Boatwake Investigations, Lowe, 40 hp, MAXPOW Tests

Date: 7/28/00														
MAXPOW Tests														
					Speed	Speed	Maximum wave Height, ft				Period of maximum wave, sec			
	Test No.	Sail	Time	Load	GPS mph	Radar mph	Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	JLW28-1	1	1129	5	25.2	24.0	0.302	0.325	0.411	0.391	1.4	1.36	1.56	1.16
	JLW28-2	1	1132	5	26.2	25.0	0.387	0.447	0.444	0.436	1.16	1.16	1.36	1.2
	JLW28-3	1	1135	5	26.4	25.0	0.292	0.325	0.411	0.412	1.32	1.36	1.2	1.24
	JLW28-4	1	1137	5	26.2	25.0	0.344	0.351	0.431	0.435	1.24	1.48	1.24	1.44
plot	JLW28-5	1	1140	5	26.2	25.0	0.311	0.337	0.408	0.432	1.28	1.2	1.2	1.48
Average					26.04	24.8	0.3272	0.357	0.421	0.4212	1.28	1.312	1.312	1.304
Std. Dev.					477	0.477	0.03871	0.05144	0.0158	0.01951				
	JLW28-6	2	1143	5	26.1	25.0	0.237	0.254	0.301	0.3	1.08	1.12	1.36	1.32
	JLW28-7	2	1146	5	25.8	24.0	0.273	0.278	0.312	0.327	1.24	1.4	1.28	1.4
	JLW28-8	2	1148	5	26.3	25.0	0.253	0.278	0.302	0.343	1.32	1.36	1.4	1.36
	JLW28-9	2	1215	5	25.1	24.0	0.305	0.311	0.338	0.334	1.2	1.28	1.24	1.44
plot	JLW28-10	2	1218	5	25.6	25.0	0.269	0.344	0.376	0.308	1.24	1.32	1.4	1.28
Average					25.78	24.6	0.2674	0.293	0.3258	0.3224	1.216	1.296	1.336	1.36
Std. Dev.					0.466	0.546	0.02539	0.03499	0.03178	0.01795				
	JLW28-11	3	1222	5	26.4	26.0	0.239	0.218	0.271	0.255	1.24	1.32	1.4	1.56
	JLW28-12	3	1225	5	25.5	25.0	0.233	0.22	0.226	0.247	1.44	0.72	0.76	1.12
	JLW28-13	3	1227	5	25.8	25.0	0.243	0.259	0.262	0.297	1.36	1.36	1.28	1.16
plot	JLW28-14	3	1230	5	25.2	24.0	0.237	0.258	0.244	0.282	1.44	1.32	1.16	1.32
	JLW28-15	3	1233	5	25.8	25.0	0.249	0.233	0.253	0.217	1.4	1.28	1.52	1.52
Average					25.74	25.0	0.2402	0.2376	0.2512	0.2596	1.376	1.2	1.224	1.336
Std. Dev.					0.445	0.707	0.0061	0.01993	0.01731	0.03121				
	JLW28-16	1	1249	4	26.4	26.0	0.299	0.305	0.398	0.388	1.04	1.28	1.4	1.16
	JLW28-17	1	1253	4	25.8	25.0	0.322	0.345	0.423	0.375	1.08	1.08	1.44	1.04
	JLW28-18	1	1255	4	24.8	24.0	0.317	0.349	0.423	0.429	1.2	1.16	1.16	1.2
	JLW28-19	1	1257	4	24.7	24.0	0.298	0.325	0.411	0.434	1.6	1.32	1.28	1.4
plot	JLW28-20	1	1301	4	25.8	25.0	0.315	0.337	0.411	0.409	1.32	1.44	1.24	1.32
Average					25.5	24.8	0.3102	0.3322	0.4132	0.407	1.248	1.256	1.304	1.224
Std.Dev.					0.728	0.837	0.01099	0.01775	0.0104	0.0255				
plot	JLW28-21	2	1305	4	26.3	26.0	0.231	0.245	0.259	0.251	1.32	1.16	1.28	1.16
	JLW28-22	2	1307	4	27.2	26.0	0.248	0.234	0.255	0.259	1.32	1.16	1.36	1.2
	JLW28-23	2	1309	4	27.5	27.0	0.226	0.244	0.263	0.224	1.32	1.36	1.32	1.24
	JLW28-24	2	1312	4	27.2	26.0	0.198	0.226	0.282	0.23	1.2	1.36	1.2	1.16
	JLW28-25	2	1314	4	27.4	27.0	0.217	0.236	0.253	0.256	1.16	1.24	1.28	1.36
Average					27.12	26.4	0.224	0.237	0.2624	0.244	1.264	1.256	1.288	1.224
Std. Dev.					0.476	0.548	0.0184	0.00781	0.01161	0.01592				
	JLW28-26	3	1318	4	27.4	27.0	0.242	0.187	0.201	0.215	1.4	1.28	1.16	1.16
	JLW28-27	3	1320	4	25.2	24.0	0.204	0.222	0.24	0.222	1.28	1.28	1.2	1.16
	JLW28-28	3	1323	4	26.4	26.0	0.219	0.226	0.22	0.208	1.32	1.52	1.28	1.52
	JLW28-29	3	1325	4	27.3	27.0	0.183	0.204	0.205	0.228	1.4	1.4	1.12	1.28
plot	JLW28-30	3	1327	4	27.4	27.0	0.189	0.206	0.21	0.2	1.32	1.28	1.4	1.24
Average					26.74	26.2	0.2074	0.209	0.2152	0.2146	1.344	1.352	1.232	1.272
Std. Dev.					0.958	1.304	0.02386	0.01562	0.01558	0.01108				
plot	JLW28-31	1	1424	3	27.4	26.0	0.247	0.284	0.335	0.322	1.2	1.12	1.24	1.2
	JLW28-32	1	1425	3	27.0	26.0	0.218	0.246	0.359	0.287	1.28	1.24	1.52	1.4
	JLW28-33	1	1428	3	27.3	26.0	0.19	0.25	0.28	0.286	1.24	1.36	1.44	1.28
	JLW28-34	1	1433	3	27.2	26.0	0.208	0.248	0.292	0.266	1.16	1.4	1.2	0.96

(Continued)

Table 10 (Concluded)

Date: 7/28/00														
MAXPOW Tests														
					Speed	Speed	Maximum wave Height, ft				Period of maximum wave, sec			
	Test No.	Sail	Time	Load	GPS mph	Radar mph	Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	JLW28-35	1	1435	3	27.5	26.0	0.28	0.297	0.328	0.373	1.32	1.32	1	1.24
Average					27.28	26.0	0.2286	0.265	0.3188	0.3068	1.24	1.288	1.28	1.216
Std. Dev.					0.192	0.0	0.03538	0.02377	0.03235	0.04214				
	JLW28-36	2	1436	3	27.1	27.0	0.195	0.216	0.241	0.184	1.28	1.44	1.36	1
	JLW28-37	2	1438	3	27.7	27.0	0.206	0.207	0.221	0.261	0.8	1.6	0.8	1.48
	JLW28-38	2	1440	3	27.4	27.0	0.2	0.212	0.244	0.26	1.16	1.24	1.2	1.44
plot	JLW28-39	2	1443	3	27.7	27.0	0.209	0.245	0.231	0.222	1.6	1.4	1.12	1.04
	JLW28-40	2	1445	3	27.0	26.0	0.207	0.235	0.226	0.236	1.28	1.16	1.24	1.24
Average					27.38	26.8	0.2034	0.223	0.2326	0.2326	1.224	1.368	1.144	1.24
Std. Dev.					0.327	0.447	0.00577	0.01623	0.00976	0.03179				
plot	JLW28-41	3	1451	3	27.4	27.0	0.193	0.198	0.201	0.203	1.24	1.2	1.24	1.12
	JLW28-42	3	1503	3	26.5	26.0	0.174	0.185	0.202	0.2	1.12	0.64	1.4	1.52
	JLW28-43	3	1506	3	27.2	26.0	0.247	0.252	0.222	0.209	1.24	1.32	1.6	1.4
	JLW28-44	3	1509	3	27.5	27.0	0.219	0.198	0.224	0.215	1.52	1.56	1.48	1.44
	JLW28-45	3	1512	3	26.5	26.0	0.216	0.244	0.224	0.221	1.2	1.44	0.72	0.64
Average					27.02	26.4	0.2098	0.2154	0.2146	0.2096	1.264	1.232	1.288	1.224
Std. Dev.					0.487	0.548	0.02771	0.03036	0.01199	0.00859				

Table 11
Johnson Lake Boatwake Investigations, Aleckson, 50 hp, MAXPOW Tests

Date: 7/28/00														
MAXPOW Tests														
					Speed GPS	Speed Radar	Maximum wave height, ft				Period of maximum wave, sec			
	Test No.	Sail	Time	Load	mph	mph	Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	JNW28-1	1	0949	3	15.2	15.0	0.315	0.413	0.462	0.473	1.44	1.32	1.56	1.32
	JNW28-2	1	0955	3	15.1	14.0	0.317	0.391	0.504	0.471	1.24	1.32	1.68	1.56
plot	JNW28-3	1	0957	3	15.0	14.0	0.343	0.406	0.459	0.491	1.4	1.72	1.56	1.32
	JNW28-4	1	1000	3	15.5	15.0	0.343	0.388	0.505	0.531	1.56	1.36	1.08	1.6
	JNW28-5	1	1003	3	15.4	15.0	0.328	0.402	0.455	0.509	1.52	1.52	1.6	1.4
Average					15.24	14.6	0.3292	0.4	0.477	0.495	1.432	1.448	1.496	1.44
Std. Dev.					0.207	0.548	0.01354	0.01042	0.02523	0.02534				
	JNW28-6	2	1011	3	14.7	14.0	0.294	0.324	0.327	0.333	1.76	1.52	1.48	1.4
	JNW28-7	2	1013	3	15.1	15.0	0.283	0.296	0.311	0.301	1.52	1.48	1.68	1.36
plot	JNW28-8	2	1018	3	15.0	14.0	0.265	0.278	0.308	0.357	1.28	1.68	1.6	1.44
	JNW28-9	2	1021	3	15.3	15.0	0.261	0.289	0.297	0.329	1.84	1.48	1.84	1.36
	JNW28-10	2	1023	3	14.9	14.0	0.264	0.288	0.332	0.391	1.48	1.4	1.92	1.32
Average					15.0	14.4	0.2734	0.295	0.315	0.3422	1.576	1.512	1.704	1.376
Std. Dev.					0.224	0.548	0.0144	0.01744	0.01434	0.03375				
	JNW28-11	3	1035	3	14.5	14.0	0.241	0.242	0.27	0.256	1.72	1.44	1.44	1.44
	JNW28-12	3	1038	3	14.3	14.0	0.243	0.244	0.273	0.293	1.72	1.84	1.68	1.44
plot	JNW28-13	3	1041	3	15.1	15.0	0.23	0.259	0.274	0.267	1.72	1.52	1.44	1.32
	JNW28-14	3	1043	3		14.0	0.232	0.246	0.27	0.267	1.4	1.36	1.48	1.36
	JNW28-15	3	1046	3	14.8	14.0	0.249	0.257	0.279	0.286	1.88	1.6	1.64	1.4
Average					14.675	14.2	0.239	0.2496	0.2732	0.2738	1.688	1.552	1.536	1.392
Std. Dev.					0.035	0.447	0.00791	0.00783	0.0037	0.01522				
	JNW28-16	1	1613	1	16.9	16.0	0.254	0.289	0.376	0.312	1.6	1.68	1.68	1.92
	JNW28-17	1	1616	1	17.0	16.0	0.278	0.255	0.324	0.36	1.64	1.88	1.92	1.2
	JNW28-18	1	1619	1	17.1	16.0	0.251	0.293	0.439	0.281	1.56	1.08	1.92	1.76
plot	JNW28-19	1	1625	1	17.0	16.0	0.246	0.281	0.339	0.336	1.24	1.08	1.28	1.44
	JNW28-20	1	1628	1	17.0	16.0	0.244	0.291	0.322	0.36	1.44	1.72	1.48	1.76
Average					17.0	16.0	0.2546	0.2818	0.36	0.3298	1.496	1.488	1.656	1.616
Std.Dev.					0.07	0.0	0.01367	0.01566	0.04919	0.03377				
	JNW28-21	2	1656	1	17.0	17.0	0.228	0.237	0.227	0.246	1.72	1.56	1.4	1.4
plot	JNW28-22	2	1658	1	17.2	17.0	0.192	0.22	0.238	0.235	1.28	1.56	1.56	1.24
	JNW28-23	2	1701	1	17.3	17.0	0.181	0.194	0.235	0.233	1.48	1.84	1.6	1.4
	JNW28-24	2	1703	1	17.3	17.0	0.189	0.187	0.212	0.231	1.6	1.48	1.56	1.56
	JNW28-25	2	1706	1	17.3	17.0	0.185	0.209	0.215	0.223	1.52	1.4	1.56	1.64
Average					17.22	17.0	0.195	0.2094	0.2254	0.2336	1.52	1.568	1.536	1.448
Std. Dev.					0.13	0.0	0.01891	0.02008	0.01163	0.00829				
	JNW28-26	3	1710	1	17.3	17.0	0.168	0.188	0.196	0.175	1.32	1.64	1.96	1.08
	JNW28-27	3	1712	1	17.3	17.0	0.161	0.173	0.186	0.177	1.44	1.2	1.28	1.36
	JNW28-28	3	1714	1	17.2	17.0	0.173	0.18	0.187	0.178	1.4	1.4	1.76	1.48
	JNW28-29	3	1719	1	17.0	17.0	0.204	0.222	0.195	0.197	1.44	1.56	1.36	1.88
plot	JNW28-30	3	1722	1	17.3	17.0	0.176	0.176	0.188	0.173	1.92	1.48	1.4	1.48
Average					17.22	17.0	0.1764	0.1878	0.1904	0.18	1.504	1.456	1.552	1.456
Std. Dev.					0.13	0.0	0.01644	0.01993	0.00472	0.0097				
plot	JNW28-31	1	1728	1	19.5	19.0	0.327	0.38	0.486	0.487	1.16	1.28	1.36	1.36
	JNW28-32	1	1731	1	19.2	18.0	0.353	0.404	0.542	0.522	1.4	1.2	1.32	1.2
	JNW28-33	1	1734	1	19.4	19.0	0.356	0.434	0.561	0.545	1.28	1.2	1.32	1.36
	JNW28-34	1	1737	1	19.8	19.0	0.354	0.42	0.502	0.449	1.2	1.36	1.2	1.16
	JNW28-35	1	1743	1	18.9	18.0	0.305	0.366	0.408	0.435	1.28	1.64	1.56	1.4
Average					19.36	18.6	0.339	0.4008	0.4998	0.4876	1.264	1.336	1.352	1.296
Std. Dev.					0.336	0.548	0.02242	0.02795	0.05947	0.04673				

Table 12
Kenai River Boatwake Investigations, Willie Predator, 35 hp, MAXPOW Tests

Date: 8/02/00

MAXPOW Tests

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of Maximum Wave, sec Gage 1	Gage 2	Gage 3	Gage 4
	KWP02-1	1/DNS	1520	6	25.8	24.0	0.594	1.061	0.856	0.815	1.36	1.08	1.16	1.24
plot	KWP02-3	1/DNS	1530	6	24.9	23.0	0.67	0.81	0.755	0.718	1.12	1.04	1.2	1.48
	KWP02-5	1/DNS	1536	6	25.9	25.0	0.734	0.568	0.737	0.934	1.36	1.44	1.48	1.64
	KWP02-7	1/DNS	1541	6	25.6	25.0	0.568	0.762	0.728	0.617	1.4	1	1.04	1.44
	KWP02-9	1/DNS	1601	6	25.6	25.0	0.597	0.788	0.612	0.628	0.92	1.28	1.08	1.16
	KWP02-11	1/DNS	1608	6	25.4	24.0	0.621	0.857	0.859	0.736	1.36	1.32	1.4	1.16
	KWP02-13	1/DNS	1615	6	25.0	24.0	0.72	0.759	0.698	0.632	1.4	1.56	1.28	1.32
	KWP02-15	1/DNS	1620	6	25.2	25.0	0.862	0.597	0.944	0.613	0.96	1.32	1.48	1.28
Average					25.425	24.375	0.67075	0.77525	0.77363	[1]	1.235	1.255	1.265	[1]
Std. Dev.					0.365	7.44	0.0981	0.15347	0.10604	[1]				
	KWP02-17	2/DNS	1708	6	25.5	25.0	0.62	0.471	0.614	0.695	1.32	1.08	1.24	1.16
	KWP02-19	2/DNS	1712	6	25.4	24.0	0.498	0.621	0.457	0.537	0.96	1.36	1.6	1.48
	KWP02-21	2/DNS	1715	6	25.4	24.0	0.539	0.498	0.774	0.598	1.2	1.44	1.24	1.08
	KWP02-23	2/DNS	1740	6	25.3	24.0	0.698	0.647	0.631	0.612	1.32	1.4	1.4	1.24
plot	KWP02-25	2/DNS	1743	6	25.0	24.0	0.538	0.595	0.553	0.623	1.24	1.16	1.2	1.32
	KWP02-27	2/DNS	1749	6	25.0	24.0	0.574	0.443	0.524	0.768	1.36	1.28	1.16	1.32
	KWP02-29	2/DNS	1755	6	24.9	24.0	0.594	0.568	0.505	0.605	1.16	1	1.52	1.28
	KWP02-31	2/DNS	1800	6	25.3	24.0	0.555	0.7	0.786	0.445	1.4	1.48	1.44	1.28
Average					25.225	24.125	0.577	0.56788	0.6055	[1]	1.245	1.275	1.35	[1]
Std. Dev.					0.225	0.354	0.0615	0.09035	0.12145	[1]				
plot	KWP02-33	3/DNS	1829	6	25.2	24.0	0.53	0.593	0.539	0.455	1.44	1.4	1.36	1.32
	KWP02-35	3/DNS	1840	6	24.9	24.0	0.513	0.557	0.778	0.63	1.32	1.24	1.2	1.2
	KWP02-37	3/DNS	1850	6	25.4	24.0	0.493	0.662	0.619	0.449	1.4	1.4	1.24	1.24
	KWP02-39	3/DNS	1857	6	25.6	24.0	0.419	0.557	0.577	0.368	1.44	1.4	1.68	1.36
	KWP02-41	3/DNS	1910	6	25.1	23.0	0.577	0.468	0.472	0.51	1.4	1.4	1.12	1.52
	KWP02-43	3/DNS	1930	6	25.0	24.0	0.558	0.656	0.493	0.501	1.32	1.4	1.32	1.4
	KWP02-45	3/DNS	1936	6	25.1	24.0	0.537	0.597	0.727	0.517	1.28	1.32	1.28	1.6
	KWP02-47	3/DNS	1940	6	25.3	24.0	0.444	0.514	0.748	0.445	1.64	1.44	1.32	1
Average					25.2	23.875	0.50888	0.5755	0.61913	[1]	1.405	1.375	1.315	[1]
Std. Dev.					0.227	0.354	0.05457	0.06628	0.11906	[1]				
	KWP02-2	1/UPS	1525	6	16.6	16.0	0.646	0.771	0.739	0.6	1.6	1.56	2.36	1.64
	KWP02-4	1/UPS	1534	6	16.2	15.0	0.569	0.687	0.754	0.667	1.68	2.28	2.2	2.24
plot	KWP02-6	1/UPS	1539	6	16.2	15.0	0.648	0.654	0.693	0.702	1.88	1.96	1.52	2.12
	KWP02-8	1/UPS	1543	6	15.7	15.0	0.592	0.827	0.672	0.696	1.56	1.96	2.24	1.96
	KWP02-10	1/UPS	1605	6	16.0	15.0	0.615	0.676	0.893	0.72	1.4	1.96	1.68	2.2
	KWP02-12	1/UPS	1611	6	16.1	15.0	0.654	0.685	0.719	0.597	1.24	2.12	2.4	2.2
	KWP02-14	1/UPS	1618	6	15.9	15.0	0.603	0.623	0.77	0.52	1.56	1.6	2.04	1.88
	KWP02-16	1/UPS	1623	6	16.0	15.0	0.661	0.804	0.707	0.752	1.64	1.8	2.28	1.72
Average					16.088	15.125	0.6235	0.71588	0.74338	[1]	1.57	1.905	2.09	[1]
Std. Dev.					0.264	0.354	0.03359	0.07463	0.06843	[1]				
	KWP02-18	2/UPS	1710	6	16.0	15.0	0.688	0.641	0.536	0.634	1.96	2.48	2.36	1.6
plot	KWP02-20	2/UPS	1714	6	15.7	14.0	0.496	0.549	0.545	0.486	1.8	1.88	1.92	1.92
	KWP02-22	2/UPS	1718	6	16.0	15.0	0.444	0.593	0.627	0.588	2.04	1.48	1.52	1.48
	KWP02-24	2/UPS	1742	6	15.0	14.0	0.696	0.857	0.513	0.516	2.08	1.72	2.16	2.12
	KWP02-26	2/UPS	1745	6	16.0	14.0	0.647	0.501	0.658	0.575	1.96	2.56	1.96	1.88
	KWP02-28	2/UPS	1753	6	16.0	14.0	0.512	0.457	0.439	0.468	1.68	1.8	2.84	1.8

(Continued)

[1] Gage 4 results used only for angle calculations because of uncertain gage operation

Table 12 (Concluded)

Date: 8/02/00														
MAXPOW Tests														
	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft				Period of Maximum Wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	KWP02-30	2/UPS	1758	6	16.1	15.0	0.728	0.702	0.553	0.604	1.76	1.72	2.24	2.88
	KWP02-32	2/UPS	1805	6	16.2	15.0	0.419	0.577	0.65	0.605	1.88	1.68	3.16	1.44
Average					15.875	14.5	0.57875	0.60963	0.56513	[1]	1.895	1.915	2.27	1.89
Std. Dev.					0.381	0.535	0.12398	0.12582	0.07529	[1]				
	KWP02-34	3/UPS	1831	6	16.2	16.0	0.465	0.591	0.587	0.532	3.28	2.08	2.72	3.08
	KWP02-36	3/UPS	1848	6	15.1	15.0	0.497	0.505	0.594	0.393	2.48	1.64	2.44	2.36
	KWP02-38	3/UPS	1854	6	16.2	15.0	0.388	0.454	0.442	0.466	2.24	1.56	1.6	4.36
plot	KWP02-40	3/UPS	1900	6	16.3	15.0	0.389	0.559	0.483	0.447	1.48	2.32	2.52	2.2
	KWP02-42	3/UPS	1915	6	15.8	14.0	0.477	0.668	0.449	0.376	2.48	1.96	2.96	2.44
	KWP02-44	3/UPS	1934	6	16.1	15.0	0.439	0.532	0.417	0.458	2.8	3.68	1.48	1.36
	KWP02-46	3/UPS	1938	6	16.1	15.0	0.596	0.487	0.465	0.452	1.88	1.96	2.56	1.72
	KWP02-48	3/UPS	1943	6	16.2	15.0	0.505	0.562	0.433	0.656	2.56	2.08	2.64	3.64
Average					16.0	15.0	0.4695	0.54475	0.48375	[1]	2.4	2.16	2.365	[1]
Std. Dev.					0.393	0.535	0.06777	0.0667	0.06882	[1]				

Table 13
Kenai River Boatwake Investigations, Willie Predator, 50 hp, MAXPOW and MAXWAV Tests

Date: 8/01/00

MAXPOW Tests

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft				Period of Maximum Wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	KWP01-1	1/DNS	1050	6	29.6	25.0	0.505	0.784	0.68	0.681	1.12	1.04	1.28	1.24
	KWP01-3	1/DNS	1056	6	29.9	28.0	0.631	0.649	0.781	0.614	1.08	1.36	1.28	1.36
	KWP01-5	1/DNS	1107	6	28.2	22.0	0.724	0.64	0.648	0.727	1.24	1.4	1.48	1.24
	KWP01-7	1/DNS	1112	6	30.4	30.0	0.539	0.572	0.89	0.736	1.76	1.32	1.2	1.4
	KWP01-9	1/DNS	1120	6	30.2	29.0	0.531	0.611	0.686	0.624	1.24	1.44	1.04	1.32
	KWP01-11	1/DNS	1128	6	30.2	30.0	0.649	0.619	0.616	0.75	1.4	1.36	1.36	1.16
plot	KWP01-13	1/DNS	1135	6	30.3	29.0	0.633	0.728	0.642	0.782	1.2	1.44	1.16	1.36
	KWP01-15	1/DNS	1141	6	30.3	29.0	0.725	0.571	0.64	0.759	1.24	1.28	1.04	1.04
Average					29.89	27.75	0.61713	0.64675	0.69788	[1]	1.285	1.33	1.23	[1]
Std. Dev.					0.73	2.82	0.08503	0.07451	0.09254	[1]				
	KWP01-17	2/DNS	1337	6	30.4	30.0	0.461	0.497	0.475	0.422	1.28	1.08	1.08	1.08
plot	KWP01-19	2/DNS	1343	6	30.3	30.0	0.474	0.519	0.505	0.516	1.48	1.32	1.44	1.4
	KWP01-21	2/DNS	1349	6	30.2	30.0	0.436	0.548	0.544	0.448	1.12	1.6	1.16	1
	KWP01-23	2/DNS	1358	6	30.6	30.0	0.435	0.497	0.448	0.389	1.28	1.24	1.24	1.08
	KWP01-25	2/DNS	1514	6	30.5	30.0	0.458	0.556	0.485	0.414	1.64	1.16	1.16	1.64
	KWP01-27	2/DNS	1518	6	30.3	30.0	0.47	0.438	0.538	0.556	1.44	1.72	1.44	1.64
	KWP01-29	2/DNS	1523	6	30.4	30.0	0.356	0.4	0.61	0.498	1.12	1.72	1.32	1.64
	KWP01-31	2/DNS	1529	6	30.4	30.0	0.503	0.51	0.499	0.523	1.56	1.68	1.48	1.48
Average					30.388	30.0	0.44913	0.49563	0.513	[1]	1.365	1.44	1.29	[1]
Std. Dev.	–				0.125	0.0	0.04346	0.05293	0.0503	[1]				
	KWP01-33	3/DNS	1544	6	30.3	29.0	0.433	0.424	0.478	0.437	1.48	1.56	1.8	1.44
plot	KWP01-35	3/DNS	1551	6	29.9	29.0	0.372	0.406	0.491	0.412	1.64	1.36	1.4	2.08
	KWP01-37	3/DNS	1558	6	30.3	30.0	0.344	0.426	0.498	0.482	2.28	1.52	1.28	1.12
	KWP01-39	3/DNS	1606	6	30.4	30.0	0.303	0.464	0.581	0.394	2.76	1.04	1.36	1.36
	KWP01-41	3/DNS	1720	6	29.9	29.0	0.457	0.418	0.464	0.383	1.36	1.36	1.36	1.36
	KWP01-43	3/DNS	1727	6	29.7	29.0	0.374	0.439	0.422	0.358	1.44	1.92	1.52	1.12
	KWP01-45	3/DNS	1738	6	29.6	29.0	0.41	0.406	0.428	0.449	1.28	1.6	1.48	1.76
	KWP01-47	3/DNS	1745	6	29.6	29.0	0.35	0.372	0.58	0.421	1.28	1.64	1.8	1.88
Average					29.963	29.25	0.38038	0.41938	0.49275	[1]	1.69	1.5	1.5	[1]
Std. Dev.					0.329	0.463	0.05051	0.02685	0.06056	[1]				
	KWP01-2	1/UPS	1052	6	20.8	20.0	0.655	0.721	0.613	0.728	1.84	1.76	1.68	1.84
plot	KWP01-4	1/UPS	1103	6	20.6	19.0	0.568	0.68	0.753	0.63	1.48	1.8	1.64	1.88
	KWP01-6	1/UPS	1109	6	20.8	20.0	0.574	0.616	0.591	0.573	1.6	1.76	2.12	2.2
	KWP01-8	1/UPS	1115	6	20.6	20.0	0.615	0.514	0.815	0.676	1.64	1.16	1.48	2.16
	KWP01-10	1/UPS	1125	6	20.8	20.0	0.535	0.68	0.664	0.576	1.68	1.88	1.88	2.24
	KWP01-12	1/UPS	1131	6	20.6	20.0	0.494	0.683	0.689	0.677	1.52	1.84	1.64	2.2
	KWP01-14	1/UPS	1138	6	20.8	19.0	0.47	0.565	0.687	0.638	1.56	1.84	2.2	2.08
	KWP01-16	1/UPS	1144	6	20.8	19.0	0.608	0.586	0.825	0.748	1.56	2	1.6	1.56
Average					20.725	19.625	0.56488	0.63063	0.70463	[1]	1.61	1.755	1.78	[1]
Std. Dev.					0.104	0.518	0.06268	0.07161	0.08662	[1]				
	KWP01-18	2/UPS	1340	6	20.4	20.0	0.506	0.716	0.579	0.417	1.4	2.64	2.4	1.6
	KWP01-20	2/UPS	1345	6	20.2	20.0	0.409	0.534	0.512	0.518	1.72	2.24	1.88	1.48
plot	KWP01-22	2/UPS	1352	6	20.5	20.0	0.479	0.56	0.559	0.51	2	1.6	1.88	1.44
	KWP01-24	2/UPS	1400	6	20.5	20.0	0.535	0.598	0.684	0.412	1.32	1.28	1.44	1.4

[1] Gage 4 results used only for angle calculations because of uncertain gage operation.

Table 13 (Continued)

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft Gage 1	Gage 2	Gage 3	Gage 4	Period of Maximum Wave, sec Gage 1	Gage 2	Gage 3	Gage 4
Date: 8/01/00														
MAXPOW Tests														
	KWP01-26	2/UPS	1516	6	20.3	19.0	0.484	0.495	0.58	0.44	2.16	1.52	1.88	1.28
	KWP01-28	2/UPS	1520	6	20.1	19.0	0.491	0.498	0.543	0.415	2.16	2.32	1.76	5.36
	KWP01-30	2/UPS	1526	6	19.7	19.0	0.493	0.478	0.632	0.54	1.52	1.8	1.76	2.16
	KWP01-32	2/UPS	1531	6	20.4	20.0	0.414	0.48	0.508	0.497	2.2	1.96	1.8	2.08
Average					20.263	19.625	0.47638	0.54488	0.57463	[1]	1.81	1.92	1.85	[1]
Std. Dev.					0.267	0.518	0.04359	0.0809	0.05965	[1]				
	KWP01-34	3/UPS	1547	6	19.5	19.0	0.42	0.399	0.526	0.518	1.76	1.24	2.64	1.16
	KWP01-36	3/UPS	1555	6	19.5	19.0	0.443	0.6	0.503	0.447	1.76	2.08	1.88	1.72
plot	KWP01-38	3/UPS	1602	6	19.9	20.0	0.414	0.523	0.501	0.432	1.88	1.56	1.56	1.96
	KWP01-40	3/UPS	1610	6	19.7	19.0	0.387	0.463	0.514	0.528	1.96	3.52	2.36	1.44
	KWP01-42	3/UPS	1723	6	19.5	20.0	0.373	0.522	0.446	0.42	1.92	2.08	1.56	1.68
	KWP01-44	3/UPS	1734	6	20.2	19.0	0.397	0.559	0.557	0.333	1.88	1.68	2.96	5.04
	KWP01-46	3/UPS	1742	6	19.8	19.0	0.39	0.434	0.552	0.431	1.36	3.36	2.32	1.92
	KWP01-48	3/UPS	1748	6	19.8	19.0	0.39	0.568	0.676	0.445	2.04	1.84	1.6	2.28
Average					19.738	19.25	0.40175	0.5085	0.53438	[1]	1.82	2.17	2.11	[1]
Std. Dev.					0.245	0.463	0.02245	0.07017	0.06684	[1]				
MAXWAV Tests														
Search for Maximum Wave														
	KWP01-49	1/DNS		6	12.8		0.731	0.622	0.785	0.7	1.12	1.32	1.56	1.56
	KWP01-51	1/DNS		6	13.6		0.761	0.861	0.961	0.741	1.56	1.76	1.48	1.68
	KWP01-53	1/DNS		6	14.0		0.646	0.823	0.956	0.813	2.48	1.2	2.6	2.24
	KWP01-55	1/DNS		6	15.4		0.645	0.73	0.829	0.642	1.16	1.08	1.68	1.96
	KWP01-57	1/DNS		6	13.0		0.821	0.858	0.934	0.824	1.4	1.48	1.44	1.4
	KWP01-59	1/DNS		6	11.6		0.329	0.724	0.532	0.482	1.2	1	0.76	1
Maximum Wave Found a 13.0 mph														
plot	***KWP01-57***	***1/DNS***		***6***	***13.0***		0.821	0.858	0.934	0.824	1.4	1.48	1.44	1.4
	KWP01-61	1/DNS		6	13.0		0.565	0.724	0.974	0.854	1.12	1.36	1.4	1.28
	KWP01-63	1/DNS		6	12.7		0.659	0.83	1.218	1.056	1.28	1.48	1.24	1.48
	KWP01-65	1/DNS		6	12.8		0.869	0.676	1.139	0.882	1.36	1.36	1.4	1.24
	KWP01-67	1/DNS		6	13.1		0.943	0.881	1.099	0.906	1.56	1.4	1.72	1.64
	KWP01-69	1/DNS		6	12.9		0.754	0.883	0.762	0.672	1.44	1.4	1.44	1.64
	KWP01-71	1/DNS		6	13.5		0.672	0.931	1.219	1.003	1.64	1.36	1.16	1.76
	KWP01-73	1/DNS		6	12.5		0.757	0.7	0.876	0.716	1.32	1.48	1.28	1.28
Average					12.938		0.755	0.81038	1.02763	[1]	1.39	1.415	1.385	[1]
Std. Dev.					0.297		0.12242	0.09649	0.16714	[1]				
Search for Maximum Wave														
	KWP01-50	1/UPS		6	5.8		0.796	0.869	1.104	0.903	3.8	4.4	4.4	4.48
	KWP01-52	1/UPS		6	8.5		0.608	0.825	0.84	0.833	2.68	2.4	2.16	2.4
	KWP01-54	1/UPS		6	6.9		0.693	0.749	0.86	0.886	3.28	3.52	2.96	3.56
	KWP01-56	1/UPS		6	5.2		0.759	1.024	1.074	0.915	3.48	3.08	4	3.48
	KWP01-58	1/UPS		6	4.3		0.483	0.946	1.004	0.871	2.84	4	3.08	3.88
	KWP01-60	1/UPS		6	5.2		0.815	0.88	1.249	1.032	3.52	3.52	3.32	2.92
Maximum Wave Found at 5.2 mph														
	KWP01-56	***1/UPS***		***6***	***5.2***		0.759	1.024	1.074	0.915	3.48	3.08	4	3.48
	KWP01-60	***1/UPS***		***6***	***5.2***		0.815	0.88	1.249	1.032	3.52	3.52	3.32	2.92
	KWP01-62	1/UPS		6	5.2		0.812	0.972	1.064	0.952	3.12	3.28	3.12	3.76
plot	KWP01-64	1/UPS		6	5.3		0.869	1.021	1.172	1.114	3.4	3.2	4.36	3.28

Table 13 (Concluded)

Date: 8/01/00														
MAXWAV Tests (Continued)														
					Speed	Speed	Maximum Wave Height, ft				Period of Maximum Wave, sec			
	Test No.	Sail	Time	Load	GPS mph	Radar mph	Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	KWP01-66	1/UPS		6	5.4		0.907	0.934	1.289	1.028	3.08	3.64	3.84	3.8
	KWP01-68	1/UPS		6	5.0		0.995	1.045	1.241	0.986	3.24	3.32	3.76	3.32
	KWP01-70	1/UPS		6	5.4		0.897	1.033	1.109	0.942	3.04	4.2	3.32	3.76
	KWP01-72	1/UPS		6	5.2		0.832	1.004	1.148	0.986	3.4	3.8	3.64	3.68
Average					5.238		0.86075	0.98913	1.16825	[1]	3.285	3.505	3.67	[1]
Std. Dev.					0.13		0.07289	0.057	0.08458	[1]				
	KWP01-75	2/DNS		6	13.0		0.407	0.627	0.709	0.7	1.4	1.28	1.4	1.32
	KWP01-77	2/DNS		6	12.6		0.43	0.491	0.549	0.364	1.12	1.24	1.56	1.36
	KWP01-79	2/DNS		6	13.0		0.416	0.574	0.706	0.52	1.12	1.2	1.28	1.2
plot	KWP01-81	2/DNS		6	13.1		0.466	0.552	0.653	0.563	1.56	1.24	1.44	1.6
	KWP01-83	2/DNS		6	12.8		0.492	0.39	0.604	0.624	1.08	1.4	1.56	1.56
	KWP01-85	2/DNS		6	13.0		0.47	0.466	0.475	0.421	1.2	1.48	1.56	1.24
	KWP01-87	2/DNS		6	13.3		0.679	0.561	0.71	0.724	1.48	1.84	1.44	1.68
	KWP01-89	2/DNS		6	13.1		0.598	0.546	0.691	0.626	1.56	1.36	1.4	1.36
Average					12.988		0.49475	0.52588	0.63713	[1]	1.315	1.38	1.455	[1]
Std. Dev.					0.21		0.09573	0.0738	0.08744	[1]				
	KWP01-76	2/UPS		6	5.0		0.518	0.667	0.743	0.733	4.32	2.76	3.88	3.44
plot	KWP01-78	2/UPS		6	5.1		0.558	0.657	0.919	0.903	3.92	3.16	3.56	4.2
	KWP01-80	2/UPS		6	4.9		0.703	0.804	0.919	0.864	3.68	4.12	2.84	3.08
	KWP01-82	2/UPS		6	4.9		0.747	0.766	0.904	0.757	2.84	2.08	4.12	3.24
	KWP01-84	2/UPS		6	5.2		0.609	0.722	0.979	0.944	3.16	3.48	3.68	3.36
	KWP01-86	2/UPS		6	5.5		0.468	0.678	0.777	0.632	2.84	4.04	3.56	3.52
	KWP01-88	2/UPS		6	5.3		0.709	0.725	0.91	0.757	2.92	2.8	4.16	2.8
	KWP01-90	2/UPS		6	5.4		0.645	0.908	1.048	0.816	3.08	3.8	3.88	3.36
Average					5.163		0.61963	0.74088	0.89988	[1]	3.345	3.28	3.71	[1]
Std. Dev.					0.226		0.09931	0.08418	0.09911	[1]				

(Sheet 3 of 3)

Table 14
Kenai River Boatwake Investigations, Koeffler, 35 hp, MAXPOW Tests

Date: 8/02/00														
MAXPOW Tests														
					Speed	Speed	Maximum Wave Height, ft				Period of Maximum Wave, sec			
	Test No.	Sail	Time	Load	GPS mph	Radar mph	Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	KKF02-1	1/DNS	0945	6	27.1	27.0	0.43	0.481	0.544	0.367	0.96	1.36	1.04	1.48
	KKF02-3	1/DNS	0950	6	27.0	26.0	0.389	0.467	0.396	0.402	1.72	1.08	1.56	1.24
	KKF02-5	1/DNS	0955	6	27.0	26.0	0.448	0.337	0.553	0.404	0.96	1.56	1.2	1.12
plot	KKF02-7	1/DNS	1002	6	27.6	27.0	0.412	0.4	0.497	0.491	1	0.96	1.2	1.44
	KKF02-9	1/DNS		6	27.4	27.0	0.559	0.415	0.498	0.476	1.12	1.2	1.16	1.04
	KKF02-11	1/DNS		6	27.5	27.0	0.546	0.396	0.442	0.522	1.44	0.96	1.2	1.16
	KKF02-13	1/DNS		6	27.6	27.0	0.431	0.561	0.433	0.435	1.16	1.28	1.36	1.12
	KKF02-15	1/DNS		6	27.5	27.0	0.357	0.532	0.452	0.571	1.28	1.2	1.44	1.12
Average					27.338	26.75	0.4465	0.44863	0.47688	[1]	1.205	1.2	1.27	[1]
Std. Dev.					0.262	0.463	0.07129	0.0753	0.05536	[1]				
	KKF02-17	2/DNS		6	27.4	26.0	0.312	0.383	0.349	0.355	1.16	1.04	1.28	1.28
	KKF02-19	2/DNS	1107	6	27.5	27.0	0.329	0.327	0.474	0.428	1.76	1.08	1.28	1
	KKF02-21	2/DNS	1115	6	27.5	27.0	0.386	0.304	0.464	0.355	1.08	1.4	1	1.4
	KKF02-23	2/DNS	1130	6	27.6	27.0	0.337	0.464	0.361	0.301	1.36	1.24	0.96	1.72
plot	KKF02-25	2/DNS	1152	6	27.4	26.0	0.404	0.42	0.461	0.373	1	1.48	1.4	1.44
	KKF02-27	2/DNS	1200	6	27.5	27.0	0.292	0.323	0.361	0.322	1.24	1.48	1.68	1.24
	KKF02-29	2/DNS	1206	6	27.0	26.0	0.278	0.453	0.374	0.406	1.24	1.16	1.04	1.36
	KKF02-31	2/DNS		6	26.9	26.0	0.344	0.429	0.57	0.354	1.24	1.24	1.36	1.24
Average					27.35	26.5	0.33525	0.38788	0.42675	[1]	1.26	1.265	1.25	[1]
Std. Dev.					0.256	0.535	0.04328	0.06294	0.07818	[1]				
plot	KKF02-33	3/DNS	1230	6	27.1	28.0	0.305	0.332	0.297	0.29	1.4	1.4	1.4	1.08
	KKF02-35	3/DNS	1238	6	27.0	26.0	0.295	0.309	0.329	0.303	1.48	1.56	1.28	1.44
	KKF02-37	3/DNS	1242	6	26.9	26.0	0.311	0.311	0.399	0.316	1.12	1.32	1.24	1.36
	KKF02-39	3/DNS	1250	6	27.0	26.0	0.285	0.293	0.376	0.346	1.4	1.48	1.36	0.96
	KKF02-41	3/DNS	1310	6	27.0	26.0	0.322	0.43	0.277	0.416	1.16	1.16	2.12	2.08
	KKF02-43	3/DNS	1314	6	27.3	26.0	0.374	0.31	0.313	0.232	1.32	1.6	2.72	1.12
	KKF02-45	3/DNS	1320	6	27.3	27.0	0.325	0.429	0.402	0.366	1.32	1.36	1.36	1.32
	KKF02-47	3/DNS	1328	6	27.4	26.0	0.305	0.263	0.317	0.251	1.68	1.72	0.92	1.36
Average					27.125	26.375	0.31525	0.33463	0.33875	[1]	1.36	1.45	1.55	[1]
Std. Dev.					0.183	0.744	0.02711	0.06175	0.04752	[1]				
	KKF02-2	1/UPS	0948	6	17.9	17.0	0.468	0.464	0.404	0.522	1.64	1.44	2.8	1.56
	KKF02-4	1/UPS	0952	6	17.7	18.0	0.388	0.424	0.579	0.418	1.72	1.84	2	2
	KKF02-6	1/UPS	1000	6	18.1	17.0	0.49	0.444	0.5	0.452	1.08	1.68	2.16	2.36
	KKF02-8	1/UPS		6	17.9	18.0	0.367	0.356	0.477	0.411	2.12	1.84	1.92	2.16
	KKF02-10	1/UPS		6	18.0	19.0	0.449	0.461	0.449	0.47	2.48	1.84	1.8	1.8
	KKF02-12	1/UPS		6	17.9	17.0	0.474	0.46	0.529	0.545	1.76	1.88	2.52	1.36
plot	KKF02-14	1/UPS		6	18.0	17.0	0.446	0.455	0.476	0.489	2.28	1.72	1.8	2.4
	KKF02-16	1/UPS		6	18.2	17.0	0.436	0.556	0.46	0.489	1.48	1.68	1.6	1.64
Average					17.963	17.5	0.43975	0.4525	0.48425	[1]	1.82	1.74	2.075	[1]
Std. Dev.					1.51	0.756	0.04244	0.055	0.05294	[1]				
	KKF02-18	2/UPS	1105	6	18.0	17.0	0.244	0.289	0.382	0.391	1.56	0.96	1.72	3.04
	KKF02-20	2/UPS	1112	6	17.8	17.0	0.294	0.417	0.49	0.313	1.24	1.2	1.12	1.8
	KKF02-22	2/UPS	1120	6	17.6	17.0	0.345	0.34	0.419	0.346	2.92	2.28	1.92	3.24
	KKF02-24	2/UPS	1135	6	17.7	18.0	0.293	0.364	0.371	0.364	1.96	1.56	2.04	1.72
plot	KKF02-26	2/UPS	1156	6	17.7	17.0	0.413	0.414	0.401	0.318	4.2	1.64	1.28	1.12
	KKF02-28	2/UPS	1204	6	17.7	17.0	0.303	0.353	0.457	0.49	1.28	2.24	2.44	1.72

(Continued)

[1] Gage 4 results used only for angle calculations because of uncertain gage operation.

Table 14 (Concluded)

Date: 8/02/00													
MAXPOW Tests													
	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft				Period of Maximum Wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
	KKF02-30	2/UPS	1208	6	17.7	16.0	0.394	0.497	0.488	0.409	2.16	1.6	2.48	1.56
	KKF02-32	2/UPS		6	17.7	16.0	0.249	0.381	0.4	0.385	1.04	1.56	5.88	5.12
Average					17.738	16.875	0.31688	0.38188	0.426	1	2.045	1.63	2.36	1
Std. Dev.					0.119	0.641	0.06232	0.06217	0.04662	1				
	KKF02-34	3/UPS	1235	6	17.8	17.0	0.261	0.396	0.357	0.318	2.04	1.56	1.28	1.64
	KKF02-36	3/UPS	1239	6	17.6	17.0	0.396	0.424	0.478	0.388	1.4	1.08	1.48	1.48
	KKF02-38	3/UPS	1245	6	17.6	17.0	0.313	0.386	0.415	0.346	2.04	1.8	2.64	2.8
	KKF02-40	3/UPS	1305	6	17.5	16.0	0.314	0.259	0.391	0.291	3.36	1.2	2.08	1.88
plot	KKF02-42	3/UPS	1312	6	17.3	16.0	0.374	0.369	0.355	0.299	1.92	1.64	1.76	2.64
	KKF02-44	3/UPS	1310	6	17.3	16.0	0.394	0.392	0.316	0.29	2.04	2.56	2.24	2.32
	KKF02-46	3/UPS	1322	6	17.6	16.0	0.278	0.397	0.421	0.421	3.12	1.64	1.24	2.6
	KKF02-48	3/UPS	1335	6	16.9	16.0	0.303	0.327	0.386	0.456	2.32	2.16	1.8	1.92
Average					17.45	16.375	0.32913	0.36875	0.38988	1	2.28	1.705	1.815	v
Std. Dev.					0.278	0.518	0.05226	0.0524	0.04948	1				

Table 15
Kenai River Boatwake Investigations, Koeffler, 50 hp, MAXPOW and MAXWAV Tests

Date: 8/03/00														
MAXPOW Tests														
	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft				Period of Maximum Wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
plot	KKF03-51	1/DNS		6	28.9		0.425	0.549	0.48	0.521	1.32	1.4	1.28	1.08
	KKF03-53	1/DNS		6	29.1		0.331	0.448	0.681	0.436	1.12	1.32	1.4	1.08
	KKF03-55	1/DNS		6	28.5		0.497	0.448	0.587	0.542	1.16	1.2	1.4	1
	KKF03-57	1/DNS		6	29.5		0.516	0.6	0.449	0.511	1.4	1.16	1.24	1.32
	KKF03-59	1/DNS		6	29.1		0.553	0.489	0.483	0.465	1.12	1.36	1.2	1.36
	KKF03-61	1/DNS		6	29.3		0.461	0.416	0.422	0.614	1.36	1	1.52	1.52
	KKF03-63	1/DNS		6	28.5		0.384	0.562	0.436	0.57	0.92	1.32	1	1.08
	KKF03-65	1/DNS		6	29.3		0.373	0.408	0.448	0.605	1.32	1	1.44	1.36
Average					29.025		0.4425	0.49	0.49825	0.533	1.215	1.22	1.31	1.225
Std. Dev.					0.369		0.07738	0.0722	0.08982	0.06308				
	KKF03-67	2/DNS		6	29.1		0.41	0.38	0.431	0.396	1.36	1.12	1.44	1.24
	KKF03-69	2/DNS		6	29.7		0.311	0.368	0.502	0.42	1.04	1.04	1.48	0.96
	KKF03-71	2/DNS		6	29.0		0.35	0.32	0.296	0.434	1.48	1.32	1.4	1.36
	KKF03-73	2/DNS		6	29.5		0.449	0.447	0.343	0.424	1.28	0.96	1.32	1.72
	KKF03-75	2/DNS		6	29.0		0.365	0.501	0.523	0.45	1.32	1.16	1.44	1.64
plot	KKF03-77	2/DNS		6	29.5		0.35	0.329	0.469	0.391	1.36	1.52	1.24	0.84
	KKF03-79	2/DNS		6	29.0		0.268	0.359	0.398	0.418	1.32	1.16	1.44	1.24
	KKF03-81	2/DNS		6	29.5		0.242	0.285	0.378	0.309	1.56	2	1.16	1.56
Average					29.288		0.34313	0.37363	0.4175	0.40525	1.34	1.285	1.365	1.32
Std. Dev.					0.29		0.06882	0.07032	0.0787	0.04328				
	KKF03-83	3/DNS		6	28.8		0.415	0.359	0.436	0.386	1.76	1.6	1.04	2.36
	KKF03-85	3/DNS		6	29.2		0.385	0.357	0.336	0.426	1.36	1.48	1.32	1.56
	KKF03-87	3/DNS		6	28.8		0.28	0.27	0.312	0.308	0.84	1.04	1	1.12
	KKF03-89	3/DNS		6	29.5		0.278	0.29	0.395	0.366	1.44	1.24	1.12	2.88
	KKF03-91	3/DNS		6	29.2		0.35	0.332	0.283	0.391	1.28	0.68	1.04	1.84
plot	KKF03-93	3/DNS		6	29.4		0.295	0.321	0.37	0.331	1.16	2.84	1.04	1.4
	KKF03-95	3/DNS		6	28.6		0.263	0.286	0.342	0.414	1.68	2	1.4	1.48
	KKF03-97	3/DNS		6	29.4		0.233	0.327	0.401	0.346	1.2	1.44	1.68	1.56
Average					29.113		0.31238	0.31775	0.35938	0.371	1.34	1.54	1.205	1.775
Std. Dev.					0.336		0.0638	0.03295	0.05058	0.04091				
	KKF03-52	1/UPS		6	21.2		0.396	0.401	0.545	0.471	2.28	1.88	1.88	1.52
	KKF03-54	1/UPS		6	21.2		0.401	0.476	0.604	0.408	1.76	2.48	1.52	1.92
plot	KKF03-56	1/UPS		6	21.3		0.453	0.425	0.556	0.399	1.88	1.68	1.52	2.04
	KKF03-58	1/UPS		6	21.4		0.49	0.434	0.447	0.442	1.96	1.92	1.72	1.88
	KKF03-60	1/UPS		6	21.3		0.486	0.485	0.499	0.478	1.88	1.64	1.6	1.52
	KKF03-62	1/UPS		6	21.5		0.592	0.419	0.471	0.401	1.56	1.48	2.12	1.96
	KKF03-64	1/UPS		6	21.5		0.381	0.439	0.493	0.37	1.84	2.4	1.64	1.72
	KKF03-66	1/UPS		6	21.4		0.452	0.524	0.454	0.435	1.68	1.44	1.84	2.12
Average					21.35		0.45638	0.45038	0.50863	0.4255	1.855	1.865	1.73	1.835
Std. Dev.					0.12		0.06848	0.04095	0.05503	0.03757				
	KKF03-68	2/UPS		6	21.4		0.344	0.354	0.367	0.356	1.88	1.8	1.48	2.44
	KKF03-70	2/UPS		6	21.3		0.281	0.41	0.337	0.328	2	1.88	1.56	1.88
	KKF03-72	2/UPS		6	21.1		0.304	0.367	0.395	0.386	1.68	1.48	1.32	1.12
	KKF03-74	2/UPS		6	21.3		0.315	0.369	0.346	0.433	1.68	1.16	1.92	1.72
	KKF03-76	2/UPS		6	21.1		0.315	0.296	0.376	0.304	1.72	1.32	1.68	1.92
	KKF03-78	2/UPS		6	21.2		0.338	0.318	0.342	0.297	2.24	1.48	1.48	1.56

(Sheet 1 of 3)

[1] Gage wire broke during test.

Table 15 (Continued)

	Test No.	Sail	Time	Load	Speed GPS mph	Speed Radar mph	Maximum Wave Height, ft				Period of Maximum Wave, sec			
							Gage 1	Gage 2	Gage 3	Gage 4	Gage 1	Gage 2	Gage 3	Gage 4
Date: 8/03/00														
MAXPOW Tests														
plot	KKF03-80	2/UPS		6	21.0		0.302	0.355	0.391	0.333	1.56	2.08	2.04	1.32
	KKF03-82	2/UPS		6	21.3		0.32	0.321	0.31	0.416	1.4	1.52	1.44	1.44
Average					21.213		0.31488	0.34875	0.358	0.35663	1.77	1.59	1.615	1.675
Std. Dev.					0.136		0.02015	0.03598	0.0293	0.0506				
	KKF03-84	3/UPS		6	21.2		0.393	0.405	0.337	0.401	1.32	1.48	2.44	2.4
	KKF03-86	3/UPS		6	21.1		0.227	0.286	0.324	0.348	2.32	1.64	2.04	1.52
	KKF03-88	3/UPS		6	21.3		0.315	0.385	0.282	0.29	2.08	1.52	2.52	1.76
plot	KKF03-90	3/UPS		6	21.5		0.276	0.278	0.308	0.316	1.16	2.24	2.44	2.64
	KKF03-92	3/UPS		6	21.1		0.258	0.259	0.254	0.308	1.24	1.4	3.04	2.2
	KKF03-94	3/UPS		6	21.2		0.271	0.258	0.266	0.367	2.04	6.28	2.96	4.24
	KKF03-96	3/UPS		6	21.1		0.235	0.266	0.29	0.298	1.36	3.84	5.2	1.48
	KKF03-98	3/UPS		6	21.1		0.231	0.264	0.287	0.333	2.12	1.92	1.8	1.2
Average					21.2		0.27575	0.30013	0.2935	0.33263	1.705	2.54	2.805	2.18
Std. Dev.					0.141		0.05563	0.05955	0.02812	0.03778				
MAXWAV Tests														
Search for Maximum Wave														
	KKF03-1	1/DNS		6	12.6		0.743	0.855	0.68	0.727	1.4	1.32	1.44	1.4
	KKF03-3	1/DNS		6	13.4		0.729	0.655	0.829	0.723	1.48	1.76	1.68	1.64
	KKF03-5	1/DNS		6	16.9		0.535	0.531	0.494	0.619	1.28	1.24	1.32	1.32
	KKF03-7	1/DNS		6	15.0		0.681	0.644	0.681	0.654	2.64	2.36	2	1.24
	KKF03-9	1/DNS		6	10.0		0.391	0.466	0.358	0.343	0.76	0.6	1.16	1.08
	KKF03-11	1/DNS		6	11.5		0.449	0.544	0.38	0.382	1.12	0.96	0.92	1.56
Possible Maximum Wave at 12.6 mph (Failed)														
	KKF03-13	1/DNS		6	12.5		0.43	0.509	0.557	0.497	0.92	1.4	1	1.08
	KKF03-15	1/DNS		6	12.5		0.566	0.635	0.68	0.654	1.24	1.4	1.24	1.08
	KKF03-17	1/DNS		6	12.8		0.478	0.565	0.717	0.686	1.2	1.4	1.32	1.24
	KKF03-19	1/DNS		6	12.5		0.497	0.566	0.629	0.554	1.28	1.32	1.28	1.56
Maximum Wave Found at 13.4														
	KKF03-3	***1/DNS***		***6***	***13.4***		0.729	0.655	0.829	0.723	1.48	1.76	1.68	1.64
	KKF03-21	1/DNS		6	13.9		0.661	0.645	0.657	0.589	1.12	1.72	1.4	1.6
	KKF03-23	1/DNS		6	13.1		0.608	0.685	0.825	0.714	1.92	1.8	1.64	1.52
	KKF03-25	1/DNS		6	13.5		0.507	0.536	0.688	0.637	1.76	1.84	1.48	1.44
	KKF03-27	1/DNS		6	13.3		0.788	0.868	0.672	0.796	1.52	1.36	1.68	1.64
	KKF03-29	1/DNS		6	13.2		0.797	0.739	0.77	0.683	1.48	1.4	1.64	1.56
plot	KKF03-31	1/DNS		6	13.4		0.629	0.666	0.722	0.769	1.56	1.2	1.76	1.36
	KKF03-33	1/DNS		6	13.4		0.63	0.73	0.771	0.867	1.44	1.6	1.76	1.56
Average					13.4		0.66863	0.6905	0.74175	0.72225	1.535	1.585	1.63	1.54
Std. Dev.					0.239		0.09805	0.09506	0.06711	0.08881				
Search for Maximum Wave														
	KKF03-2	1/UPS		6	5.0		0.717	0.807	0.85	0.774	4.12	3.84	3.88	3.4
	KKF03-4	1/UPS		6	7.5		0.51	0.524	0.617	0.501	3.04	2.6	2.28	5.16
	KKF03-6	1/UPS		6	5.9		0.643	0.75	0.801	0.694	3.88	3.72	3.4	3.4
	KKF03-8	1/UPS		6	5.7		0.645	0.837	0.856	0.675	3.6	4.08	4.48	3.88
	KKF03-10	1/UPS		6	4.5		0.507	0.742	0.801	0.775	3.2	3.24	4.12	3.88
	KKF03-12	1/UPS		6	5.5		0.684	0.793	0.808	0.655	3.36	3.52	3.92	3.4
Maximum Wave Found at 5.0														
plot	***KKF03-2***	***1/UPS***		***6***	***5.0***		0.717	0.807	0.85	0.774	4.12	3.84	3.88	3.4

Table 15 (Concluded)

Date: 8/03/00														
MAXWAV Tests (Continued)														
	Test No.	**Sail**	**Time**	**Load**	**Speed GPS mph**	**Speed Radar mph**	**Maximum Wave Height, ft**				**Period of Maximum Wave, sec**			
							Gage 1	**Gage 2**	**Gage 3**	**Gage 4**	**Gage 1**	**Gage 2**	**Gage 3**	**Gage 4**
	KKF03-14	1/UPS		6	5.0		0.653	0.774	0.863	0.737	3.72	4.04	3.68	4.6
	KKF03-16	1/UPS		6	5.0		0.755	0.823	0.925	0.773	3.52	3.64	3.72	3.4
	KKF03-18	1/UPS		6	5.2		0.669	0.84	0.872	0.756	3.84	3.24	3.68	3.32
	KKF03-20	1/UPS		6	5.1		0.526	0.797	1.087	0.782	3.04	3.8	3.76	2.8
	KKF03-22	1/UPS		6	5.2		0.597	0.885	0.778	0.669	3.96	4.08	3.44	3.24
	KKF03-24	1/UPS		6	5.2		0.714	0.8	0.857	1	3.32	3.92	3.88	-0.04
	KKF03-26	1/UPS		6	5.2		0.621	0.715	0.73	0.668	3.12	4.04	4.32	3.44
Average					5.113		0.6565	0.80513	0.87025	0.737	3.58	3.825	3.795	2.68
Std. Dev.					0.099		0.07432	0.04943	0.1061	0.04905				
	KKF03-35	2/DNS		6	12.9		0.546	0.464	0.521	0.596	1.44	1.44	1.6	1.4
	KKF03-37	2/DNS		6	13.1		0.441	0.515	0.433	0.606	1.32	1.32	1.36	1.48
	KKF03-39	2/DNS		6	13.1		0.342	0.353	0.435	0.515	1.48	1.4	1.76	1.2
	KKF03-41	2/DNS		6	13.4		0.439	0.605	0.672	0.621	1.44	1.32	1.4	1.56
	KKF03-43	2/DNS		6	13.4		0.567	0.58	0.623	0.678	1.28	1.48	1.44	1.2
	KKF03-45	2/DNS		6	13.5		0.301	0.455	0.708	0.694	1.24	1.4	1.44	1.48
	KKF03-47	2/DNS		6	13.4		0.53	0.415	0.444	0.443	1.16	1.44	1.16	1.32
plot	KKF03-49	2/DNS		6	13.2		0.401	0.502	0.458	0.523	1.16	1.28	1.28	1.48
Average					13.25		0.44588	0.48613	0.53675	0.5845	1.315	1.385	1.43	1.39
Std. Dev.					0.207		0.09683	0.08304	0.11416	0.0856				
	KKF03-36	2/UPS		6	5.0		0.538	0.584	0.762	0.57	3.6	4.32	3.8	3.96
	KKF03-38	2/UPS		6	5.1		0.523	0.752	0.697	0.664	3.4	4.2	3.92	3.48
	KKF03-40	2/UPS		6	5.1		0.477	0.581	0.675	0.537	3.36	4.32	4.36	3.64
	KKF03-42	2/UPS		6	5.1		0.554	0.757	0.768	0.594	2.8	4.52	4.04	3.24
	KKF03-44	2/UPS		6	5.1		0.433	0.591	0.672	0.649	2.24	3.56	4.04	3.2
plot	KKF03-46	2/UPS		6	5.2		0.563	0.757	0.753	0.684	4.08	3.56	3.8	3.8
	KKF03-48	2/UPS		6	4.8		0.491	0.53	0.538	0.638	4.08	3	3.84	3.92
	KKF03-50	2/UPS		6	5.1		0.53	0.785	0.762	0.514	3.2	3.2	3.44	4.12
Average					5.063		0.51363	0.66713	0.70338	0.60625	3.345	3.835	3.905	3.67
Std. Dev.					0.119		0.04371	0.10432	0.0781	0.06209				

(Sheet 3 of 3)

Table 16
Froude Numbers Based on Vessel Length

Location/boat/power	Wave type	Loading	F_L
JWP35	MAXPOW	All	1.0
JWP35	MAXPOW	6 only	0.8
JWP50	MAXPOW	All	1.5
JWP50	MAXPOW	6 only	1.5
JWP	MAXWAV	All	0.7
JKF35	MAXPOW	All	1.4
JKF35	MAXPOW	6 only	1.3
JKF50	MAXPOW	All	1.6
JKF50	MAXPOW	6 only	1.5
JKF	MAXWAV	All	0.5
JKL35	MAXPOW	All	1.5
JKL40	MAXPOW	All	1.6
JKL	MAXWAV	All	0.5
JLW35	MAXPOW	All	1.6
JLW40	MAXPOW	All	1.7
JLW	MAXWAV	All	0.5
KWP35[1]	MAXPOW	6 only	1.2
KWP50[1]	MAXPOW	6 only	1.5
KWP[1]	MAXWAV	6 only	0.5
KKF35[1]	MAXPOW	6 only	1.3
KKF50[1]	MAXPOW	6 only	1.5
KKF[1]	MAXWAV	6 only	0.5

[1] Speed used in determining F_L was average of upstream and downstream runs.

Table 17
Standard Deviation of Maximum Wave Height

Boat	Average STD, ft- Johnson Lake		Average STD, ft- Kenai River	
	MAXPOW	MAXWAV	MAXPOW	MAXWAV
WP	0.027	0.026	0.074	0.095
KF	0.025	0.028	0.054	0.080
KL	0.027	0.065	Not run	Not run
LW	0.019	0.067	Not run	Not run
ANOVA of all boats	0.029	0.053	0.068	0.093

Table 18a
ANOVA for Johnson Lake MAXPOW, WP

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	0.588434	326	0.001280	459.815	0.000000
2	8	0.655924	326	0.001280	512.554	0.000000
3	1	1.66809	326	0.001280	1303.48	0.000000
12	16	0.003418	326	0.001280	2.671	0.000554
13	2	0.027839	326	0.001280	21.754	0.000000
23	8	0.000997	326	0.001280	.779	0.621711
123	16	0.001682	326	0.001280	1.314	0.185784

Note: Summary of all effects; design; (john_mpw_wp.sta)
1-LOAD, 2-SAIL, 3-POWER

Table 18b
ANOVA for Johnson Lake MAXPOW, KF

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	0.230469	306	0.000732	314.7557	0.000000
2	8	0.302693	306	0.000732	413.3948	0.000000
3	1	0.225910	306	0.000732	308.5301	0.000000
12	16	0.004883	306	0.000732	6.6692	0.000000
13	2	0.002211	306	0.000732	3.0194	0.050289
23	8	0.002385	306	0.000732	3.2577	0.001408
123	16	0.003337	306	0.000732	4.5581	0.000000

Note: Summary of all effects; design; (john_mpw_kf.sta)
1-LOAD, 2-SAIL, 3-POWER

Table 18c
ANOVA for Johnson Lake MAXPOW, KL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	0.151169	306	0.000916	164.9805	0.000000
2	8	0.311264	306	0.000916	339.7024	0.000000
3	1	0.210436	306	0.000916	229.6626	0.000000
12	16	0.002960	306	0.000916	3.2307	0.000035
13	2	0.010015	306	0.000916	10.9295	0.000026
23	8	0.001608	306	0.000916	1.7554	0.085374
123	16	0.002528	306	0.000916	2.7593	0.000372

Note: Summary of all effects; design; (john_mpw_kl.sta)
1-LOAD, 2-SAIL, 3-POWER

Table 18d
ANOVA for Johnson Lake MAXPOW, LW

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	0.134134	306	0.000420	319.5662	0.000000
2	8	0.164754	306	0.000420	392.5180	0.000000
3	1	0.024639	306	0.000420	58.7000	0.000000
12	16	0.004082	306	0.000420	9.7240	0.000000
13	2	0.002056	306	0.000420	4.8982	0.008055
23	8	0.001139	306	0.000420	2.7137	0.006689
123	16	0.000971	306	0.000420	2.3143	0.003142

Note: Summary of all effects; design; (john_mpw_lw.sta)
1-LOAD, 2-SAIL, 3-POWER

Table 18e
ANOVA for all Four Boats, Common Loadings of Three and Four People, and a Common Power of 35 hp

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	2.208937	408	0.000855	2583.711	0.000000
2	1	0.424166	408	0.000855	496.131	0.000000
3	8	0.415844	408	0.000855	486.398	0.000000
12	3	0.068519	408	0.000855	80.144	0.000000
13	24	0.012032	408	0.000855	14.073	0.000000
23	8	0.010964	408	0.000855	12.825	0.000000
123	24	0.001584	408	0.000855	1.853	0.009123

Note: Summary of all effects; design; (john_mpw_boat.sta)
1-BOAT, 2-LOAD, 3-SAIL

Table 19a
Student-Newman-Keuls Test; MAXPOW Johnson Lake (john_allmpw_hml_sta.sta), Probabilities for Post Hoc Tests, Average of All Distances and All Loads (SNK conducted separately for each boat)

Boat	Power	MAXPOW[1]	Low-High	Critical Range[2]
WP	LOW	0.621	0.00[3]	0.028
WP	HIGH	0.498		
KF	LOW	0.366	0.00	0.020
KF	HIGH	0.311		
KL	LOW	0.406	0.00	0.020
KL	HIGH	0.357		
LW	LOW	0.258	0.04	0.015
LW	HIGH	0.274		

[1] MAXPOW averaged over all distances and all loads, ft.
[2] Difference between adjacent means in rank order before considered different, ft.
[3] Probability that MAXPOW are equal.

Table 19b
Student-Newman-Keuls Test; MAXPOW Johnson Lake (john_allmpw_hml_sta.sta), Probabilities for Post Hoc Tests, Average of All Distances and All Powers (SNK conducted separately for each boat)

Boat	Load	MAXPOW[1]	Heavy-med	Heavy-light	Medium-light	Critical Range[2]
WP	HEAVY	0.620	0.00[3]	0.00	0.00	0.035
WP	MEDIUM	0.567				
WP	LIGHT	0.470				
KF	HEAVY	0.382	0.00	0.00	0.00	0.023
KF	MEDIUM	0.345				
KF	LIGHT	0.288				
KL	HEAVY	0.424	0.00	0.00	0.00	0.024
KL	MEDIUM	0.373				
KL	LIGHT	0.347				
LW	HEAVY	0.300	0.00	0.00	0.00	0.017
LW	MEDIUM	0.270				
LW	LIGHT	0.228				

[1] MAXPOW averaged over all distances and both powers.
[2] Difference between adjacent means in rank order before considered different, ft.
[3] Probability that MAXPOW are equal.

Table 19c
Student-Newman-Keuls Test; MAXPOW Johnson Lake (john_35sl34_mpw_sta.sta), Probabilities for Post Hoc Tests, MAIN EFFECT: BOAT, 3 and 4 Loads Only, 35 HP Only (SNK conducted for all boats)

Boat	MAXPOW[1]	WP-KF	WP-KL	WP-LW	KF-KL	KF-LW	KL-LW	Critical Range[2]
WP	0.589	0.00[3]	0.00	0.00	0.00	0.00	0.00	0.025
KF	0.342							
KL	0.388							
LW	0.242							

[1] MAXPOW averaged over all distances, loads of 3 and 4 persons only, 35 hp only.
[2] Difference between adjacent means in rank order before considered different, ft.
[3] Probability that MAXPOW are equal.

Table 20
ANOVA for Johnson Lake MAXWAV Tests (Stat. General Manova)

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3[1]	0.361203[1]	408[1]	0.002820[1]	128.1032[1]	0.000000[1]
2	2[1]	0.046644[1]	408[1]	0.002820[1]	16.5427[1]	0.000000[1]
3	5[1]	0.279669[1]	408[1]	0.002820[1]	99.1864[1]	0.000000[1]
12	6[1]	0.033131[1]	408[1]	0.002820[1]	11.7609[1]	0.000000[1]
13	15[1]	0.006764[1]	408[1]	0.002820	2.3989[1]	0.002437[1]
23	10	0.002850	408	0.002820	1.0106	0.433457
123	30	0.003192	408	0.002820	1.1322	0.291720

Note: Summary of all effects; design; (jall_mwh_sta.sta)
1-BOAT, 2-LOAD, 3-DISTANCE

Table 21
Student-Newman-Keuls Test; MAXWAV Johnson Lake (jall_mwh_sta.sta), Probabilities for Post Hoc Tests, Average of All Distances (4-9)

Boat	Load	MAXWAV[1]	Heavy-med	Heavy-light	Medium-light	Critical Range[2]
WP	HEAVY	0.602	0.81[3]	0.52	0.65	0.032
WP	MEDIUM	0.606				
WP	LIGHT	0.592				
KF	HEAVY	0.477	0.71	0.03	0.03	0.024
KF	MEDIUM	0.481				
KF	LIGHT	0.508				
KL	HEAVY	0.652	0.12	0.00	0.01	0.035
KL	MEDIUM	0.625				
KL	LIGHT	0.577				
LW	HEAVY	0.596	0.86	0.00	0.00	0.043
LW	MEDIUM	0.600				
LW	LIGHT	0.518				

1 MAXWAV averaged over all distances.
2 Difference between adjacent means in rank order before considered different, ft.
3 Probability that MAXWAV are equal.

Table 22
Student-Newman-Keuls Test; MAXWAV Johnson Lake (j_mwh_load34.sta), Probabilities for Post Hoc Tests, Average of Three and Four Person Loads and All Distances (4-9)

Boat	MAXWAV[1]	WP-KF	WP-KL	WP-LW	KF-KL	KF-LW	KL-LW	Critical Range[2]
WP	0.599	0.00[3]	0.89	0.00	0.00	0.00	0.00	0.026
KF	0.494							
KL	0.601							
LW	0.559							

1 MAXWAV averaged over all distances.
2 Difference between adjacent means in rank order before considered different, ft.
3 Probability that MAXWAV are equal.

Table 23 **ANOVA for Kenai River MAXPOW Tests (all tests with six loads) (Stat. General Manova)**						
Effect	**df Effect**	**MS Effect**	**df Error**	**MS Error**	**F**	**p-level**
1	1[1]	5.213380[1]	552[1]	0.004661[1]	1118.506[1]	0.000000[1]
2	1	0.011872	552	0.004661	2.547	0.111063
3	8[1]	0.403527[1]	552[1]	0.004661[1]	86.575[1]	0.000000[1]
4	1[1]	0.296580[1]	552[1]	0.004661[1]	63.630[1]	0.000000[1]
12	1	0.001131	552	0.004661	0.243	0.622553
13	8[1]	0.019901[1]	552[1]	0.004661[1]	4.270[1]	0.000054[1]
23	8	0.004452	552	0.004661	0.955	0.470355
14	1[1]	0.143077[1]	552[1]	0.004661[1]	30.697[1]	0.000000[1]
24	1	0.004708	552	0.004661	1.010	0.315349
34	8	0.004412	552	0.004661	0.946	0.477455
123	8	0.006383	552	0.004661	1.369	0.207055
124	1[1]	0.101197[1]	552[1]	0.004661[1]	21.711[1]	0.000004[1]
134	8	0.007496	552	0.004661	1.608	0.119374
234	8	0.001217	552	0.004661	0.261	0.977910
1234	8	0.008878	552	0.004661	1.905	0.057001

Note: Summary of all effects; design; (kenai_allmpw_sta.sta)
1-BOAT, 2-DIRECTION, 3-SAIL, 4-POWER

Table 24 **Student-Newman-Keuls Test; MAXPOW Kenai River (kenai_allmpw_sta.sta) Probabilities for Post Hoc Tests, INTERACTION: 1 x 2, boat versus direction (Average of all distances and powers)**				
Boat	**Direction**	**MAXPOW[1]**	**Down-Up**	**Critical Range[2]**
WP	DOWN	0.577	0.67[3]	0.029
WP	UP	0.571		
KF	DOWN	0.399	0.06	0.018
KF	UP	0.381		

[1] MAXPOW averaged over all distances and both powers.
[2] Difference between adjacent means in rank order before considered different, ft.
[3] Probability that MAXPOW are equal.

Table 25 **Student-Newman-Keuls Test; MAXPOW Kenai River (kenai_allmpw_sta.sta) Probabilities for Post Hoc Tests, INTERACTION: 1 x 2, boat versus power (Average of all distances and both directions)**				
Boat	**Power**	**MAXPOW[1]**	**Low-High**	**Critical Range[2]**
WP	LOW	0.612	0.00[3]	0.027
WP	HIGH	0.536		
KF	LOW	0.394	0.42	0.018
KF	HIGH	0.387		

[1] MAXPOW averaged over all distances and both directions.
[2] Difference between adjacent means in rank order before considered different, ft.
[3] Probability that MAXPOW are equal.

Table 26
Student-Newman-Keuls Test; MAXPOW Kenai River (kenai_allmpw_sta.sta) Probabilities for Post Hoc Tests, (Average of all distances, both powers, and both directions)

Boat	MAXPOW[1]	WP-KF	Critical Range[2]
WP	0.574	0.00[3]	0.016
KF	0.390		

[1] MAXPOW averaged over all distances, both powers, and both directions.
[2] Difference between adjacent means in rank order before considered different, ft.
[3] Probability that MAXPOW are equal.

Table 27
ANOVA for Kenai River MAXWAV Tests (all tests with six loads) (Stat. General Manova)

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1[1]	1.214211[1]	195[1]	0.008657[1]	140.2561[1]	0.000000[1]
2	1[1]	0.861137[1]	195[1]	0.008657[1]	99.4718[1]	0.000000[1]
3	5[1]	0.791211[1]	195[1]	0.008657[1]	91.3945[1]	0.000000[1]
12	1[1]	0.090410[1]	195[1]	0.008657[1]	10.4435[1]	0.001445[1]
13	5[1]	0.089690[1]	195[1]	0.008657[1]	10.3603[1]	0.000000[1]
23	5[1]	0.24128[1]	195[1]	0.008657[1]	2.7871[1]	0.018640[1]
123	5	0.005504	195	0.008657	0.6358	0.672644

Note: Summary of all effects; design; (kenai_allmwh_sta.sta)
1-BOAT, 2-DIRECT, 3-SAIL

Table 28a
Student-Newman-Keuls Test; MAXWAV Kenai River (kenai_allmpw_sta.sta) Probabilities for Post Hoc Tests, Boat Versus Direction

Boat	Direction	MAXWAV[1]	Down-Up	Critical Range[2]
WP	DOWN	0.708	0.00[3]	0.082
WP	UP	0.880		
KF	DOWN	0.602	0.00	0.046
KF	UP	0.694		

[1] MAXWAV averaged over all distances.
[2] Difference between adjacent means in rank order before considered different, ft.
[3] Probability that MAXWAV are equal.

Table 28b
Student-Newman-Keuls Test; MAXWAV Kenai River (kenai_allmpw_sta.sta) Probabilities for Post Hoc Tests, Boat

Boat	MAXWAV[1]	WP-KF	Critical Range[2]
WP	0.794	0.00[3]	0.048
KF	0.649		

[1] MAXWAV averaged over all distances and both directions.
[2] Difference between adjacent means in rank order before considered different, ft.
[3] Probability that MAXWAV are equal.

Table 29
Wave Periods for Maximum Wave, Average Period of All Distances

Location/boat/motor	Wave type	Load	Average period of all distances, sec
JWP35	MAXPOW	6	1.52
"	"	4	1.40
"	"	3	1.39
JWP50	"	6	1.39
"	"	4	1.35
"	"	3	1.32
JWP	MAXWAV	6	1.59
"	"	4	1.8
"	"	3	1.56
JKF35	MAXPOW	6	1.47
"	"	4	1.37
"	"	3	1.47
JKF50	"	6	1.36
"	"	4	1.40
"	"	3	1.39
JKF	MAXWAV	6	1.78
"	"	4	1.82
"	"	3	1.65
JKL35	MAXPOW	5	1.29
"	"	4	1.28
"	"	3	1.19
JKL40	"	5	1.29
"	"	4	1.31
"	"	3	1.24
JKL	MAXWAV	5	1.56
"	"	4	1.53
"	"	3	1.48
JLW35	MAXPOW	5	1.21
"	"	4	1.28
"	"	3	1.31
JLW40	"	5	1.30
"	"	4	1.27
"	"	3	1.25
JLW	MAXWAV	5	1.60
"	"	4	1.55
"	"	3	1.51
JNW	MAXPOW	3	1.51
"	"	1	1.52
KWP35	"	6	DS=1.30, US=2.06
KWP50	"	6	DS=1.40, US=1.87
KWP	MAXWAV	6	DS=1.39, US=3.47
KKF35	MAXPOW	6	DS=1.31, US=1.94
KKF50	"	6	DS=1.35, US=1.86
KKF	MAXWAV	6	DS=1.48, US=3.63

Table 30
Summary of Wave Period, Wavelength, and Water Depth/Wavelength Ratio

Group	Average period, sec	Wavelength at Gage 1, ft	Wavelength at Gage 3, ft	d/L_w, Gage 1	d/L_w, Gage 3
J-MAXPOW	1.34	9.2	9.2	0.64	0.98
J-MAXWAV	1.62	13.3	13.4	0.44	0.67
K-MAXPOW-DS	1.34	9.2	9.2	0.56	0.82
K-MAXPOW-US	1.93	18.1	18.8	0.28	0.40
K-MAXWAV-DS	1.44	10.6	10.6	0.49	0.71
K-MAXWAV-US	3.55	42.1	48.4	0.12	0.16

Table 31
Johnson Lake, Energy and Angle

	Test No.	Sail	Time	Load	Speed GPS mph	Energy, ft-lb/ft of wave front Gage 1	Gage 2	Gage 3	Gage 4	Angle
Willie Predator, 35 hp, MAXPOW Test										
plot	JWP24-41	1	1446	6	15.0	172.4544	179.64	199.6	239.52	13.3
plot	JWP24-49	2	1534	6	14.3	167.2648	164.0712	162.4744	179.64	12.8
plot	JWP24-53	3	1554	6	14.8	150.8976	172.0552	161.676	172.0552	12.5
plot	JWP24-76	1	1905	4	19.5	118.1632	112.9736	124.5504	146.9056	8.8
plot	JWP24-77	2	1910	4	19.7	114.1712	122.9536	133.3328	122.5544	7.5
plot	JWP24-84	3	1953	4	19.5	120.9576	131.3368	133.3328	138.9216	6.9
plot	JWP24-100	1	2130	3	21.3	93.0136	97.4048	97.804	106.9856	7.6
plot	JWP24-107	2	2157	3	21.5	93.812	89.4208	93.812	100.1992	6.9
plot	JWP24-112	3	2215	3	21.8	90.6184	91.0176	97.0056	92.2152	5.1
Willie Predator MAXWAV Tests										
plot	JWP24-64	2		6	13.0	164.0712	167.2648	139.3208	169.66	13.0
plot	JWP24-67	3		6	13.0	172.4544	154.0912	166.0672	169.66	8.9
plot	JWP24-91	2		4	9.7	154.0912	158.8816	132.5344	158.4824	17.9
plot	JWP24-99	3		4	9.2	112.9736	116.1672	122.1552	124.9496	18.2
plot	JWP24-120	2		3	12.0	150.0992	142.1152	149.7	163.672	13.2
plot	JWP24-126	3		3	11.3	153.692	148.9016	166.4664	174.4504	11.1
Willie Predator, 50 hp, MAXPOW Tests										
plot	JWP23-5	1	2009	6	24.8	96.6064	109.78	110.9776	106.5864	5.1
plot	JWP24-3	2	835	6	25.1	90.6184	91.816	99.8	106.1872	5.8
plot	JWP24-6	3	851	6	25.1	91.816	87.824	89.4208	95.4088	3.8
plot	JWP24-11	1	928	3	27.4	68.2632	67.864	65.868	68.6624	5.9
plot	JWP24-16	2	950	3	27.3	62.6744	57.884	62.2752	61.876	5.4
plot	JWP24-22	3	1026	3	27.3	56.2872	61.4768	64.6704	57.4848	2.1
plot	JWP24-28	1	1141	4	26.0	78.2432	77.4448	78.2432	79.0416	6.1
plot	JWP24-33	2	1205	4	26.4	73.0536	76.6464	74.6504	73.852	5.1
plot	JWP24-39	3	1237	4	26.2	62.2752	73.0536	76.6464	75.848	2.5
Koeffler, 35 hp, MAXPOW Tests										
plot	JKF27-22	1	1219	6	22.4	65.0696	80.6384	82.2352	75.4488	6.9
plot	JKF27-29	2	1246	6	22.4	70.6584	70.6584	67.0656	82.2352	5.7
plot	JKF27-32	3	1254	6	22.2	68.6624	74.6504	65.868	73.852	4.3
plot	JKF27-41	1	1412	4	23.6	65.868	53.0936	86.2272	49.5008	6.7
plot	JKF27-46	2	1424	4	23.3	42.7144	46.3072	45.908	69.0616	6.4
plot	JKF27-48	3	1434	4	23.3	66.6664	52.6944	62.6744	69.0616	4.5
plot	JKF27-53	1	1540	3	25.2	41.5168	49.5008	44.3112	51.0976	6.1
plot	JKF27-59	2	1600	3	25.2	48.3032	39.1216	47.5048	49.1016	6.9
plot	JKF27-64	3	1614	3	25.3	38.3232	42.3152	48.7024	50.2992	4.7
Koeffler, MAXWAV Tests										
plot	JKF27-15	2		6	8.7	62.6744	75.848	89.0216	84.2312	21.4
plot	JKF27-18	3		6	8.4	55.888	89.82	95.4088	94.2112	21.4
plot	JKF25-40	2		4	13.8	97.0056	96.6064	109.78	97.0056	9.3
plot	JKF25-46	2		4	15.5	80.6384	86.6264	71.0576	77.0456	10.4
plot	JKF25-47	2		4	9.1	97.804	168.8616	103.3928	82.2352	13.4

(Sheet 1 of 3)

Table 31 (Continued)										
Koeffler, MAXWAV Tests (Continued)										
	Test No.	**Sail**	**Time**	**Load**	**Speed GPS mph**	**Energy, ft-lb/ft of wave front**				**Angle**
						Gage 1	**Gage 2**	**Gage 3**	**Gage 4**	
plot	JKF25-55	3		4	9.3	67.4648	84.6304	100.1992	97.0056	19.3
plot	JKF25-78	2		3	8.1	72.2552	81.0376	81.0376	84.2312	19.0
plot	JKF25-83	3		3	8.1	55.888	73.0536	89.82	73.0536	20.1
Koeffler, 50 hp, MAXPOW Test										
plot	JKF25-4	1	1224	6	26.2	46.3072	51.896	51.4968	57.4848	6.0
plot	JKF25-7	2	1244	6	25.7	57.4848	49.5008	53.0936	47.5048	4.9
plot	JKF25-12	3		6	27.4	49.1016	53.892	57.884	54.2912	2.0
plot	JKF25-18	1	1426	4	28.4	45.908	43.5128	40.7184	39.5208	6.2
plot	JKF25-24	2	1450	4	28.3	44.3112	50.6984	39.92	49.9	3.6
plot	JKF25-26	3	1459	4	28.3	46.7064	37.924	37.5248	47.904	7.2
plot	JKF25-58	1	1832	3	27.0	48.3032	50.6984	31.936	13.972	5.4
plot	JKF25-65	2	1855	3	27.5	32.7344	36.3272	37.924	38.7224	6.1
plot	JKF25-67	3	1903	3	27.4	27.944	43.1136	36.7264	37.1256	3.7
Klamath, 35 hp, MAXPOW Tests										
plot	JKL26-33	1	1411	3	24.7	43.1136	53.0936	41.1176	36.7264	7.7
plot	JKL26-38	2	1515	3	24.1	45.908	54.6904	48.7024	54.2912	7.2
plot	JKL26-42	3	1526	3	24.0	61.4768	48.7024	49.1016	60.2792	4.3
plot	JKL26-86	1	1946	4	23.4	50.6984	55.888	62.2752	66.6664	6.6
plot	JKL26-90	2	2000	4	23.4	60.6784	64.6704	55.888	55.888	6.0
plot	JKL26-95	3	2017	4	23.2	61.0776	58.2832	50.2992	59.88	8.1
plot	JKL26-1	1	938	5	23.3	63.0736	60.2792	76.6464	66.6664	5.7
plot	JKL26-9	2	1011	5	23.0	55.0896	78.6424	57.4848	79.84	4.9
plot	JKL26-14	3		5	23.2	56.2872	60.6784	57.4848	57.0856	3.3
Klamath, MAXWAV Tests										
plot	JKL26-53	2		3	8.6	79.0416	92.6144	103.3928	98.6024	18.9
plot	JKL26-59	3		3	8.2	100.1992	106.9856	118.9616	95.4088	16.7
plot	JKL26-63	2		3	7.7	73.0536	74.6504	65.868	77.4448	16.8
plot	JKL26-66	3		3	7.8	74.2512	88.6224	96.2072	72.2552	13.4
plot	JKL26-78	2		4	8.4	86.2272	123.3528	103.792	101.796	19.3
plot	JKL26-82	3		4	8.5	77.4448	140.5184	118.9616	100.9976	14.4
plot	JKL26-25	2		5	8.6	61.876	134.1312	192.0152	181.2368	24.2
plot	JKL26-26	3		5	8.4	114.5704	110.1792	119.3608	111.776	16.6
Klamath, 40 hp, MAXPOW Tests										
plot	JKL27-4	1	1736	5	24.3	51.4968	63.872	65.0696	65.868	3.7
plot	JKL27-9	2	1749	5	24.9	43.912	56.2872	59.0816	66.6664	5.6
plot	JKL27-12	3	1757	5	24.7	51.0976	66.6664	63.4728	80.2392	4.1
plot	JKL27-16	1	1816	4	24.9	45.5088	45.5088	42.3152	50.6984	6.7
plot	JKL27-23	2	1833	4	24.7	39.92	47.904	57.884	49.9	8.8
plot	JKL27-26	3	1844	4	25.3	44.3112	42.7144	48.7024	47.1056	3.3
plot	JKL27-33	1	1911	3	26.6	37.5248	36.3272	53.4928	43.1136	4.7
plot	JKL27-39	2	1932	3	24.5	33.932	32.3352	43.912	42.3152	3.8
plot	JKL27-43	3	1943	3	25.3	27.5448	38.3232	29.1416	44.3112	5.0
Lowe, 35 hp, MAXPOW Tests										
plot	JLW28-46	1	1852	3	25.6	22.7544	23.952	20.3592	17.5648	6.0
										(Sheet 2 of 3)

Table 31 (Concluded)

	Test No.	Sail	Time	Load	Speed GPS mph	Energy, ft-lb/ft of wave front Gage 1	Gage 2	Gage 3	Gage 4	Angle
Lowe, 35 hp, MAXPOW Tests (Continued)										
plot	JLW28-53	2	1916	3	25.0	18.7624	24.7504	23.5528	26.7464	6.5
plot	JLW28-58	3	1932	3	25.5	23.1536	28.3432	28.3432	22.7544	2.2
plot	JLW29-39	1	1112	4	25.3	30.3392	32.3352	30.3392	32.7344	5.6
plot	JLW29-43	2	1123	4	25.7	26.3472	30.3392	27.1456	26.7464	6.5
plot	JLW29-49	3	1139	4	25.5	27.5448	33.5328	36.7264	31.1376	1.4
plot	JLW29-75	1	1432	5	24.5	35.1296	33.1336	33.5328	39.1216	6.0
plot	JLW29-79	2	1442	5	24.2	34.7304	41.916	33.1336	38.7224	4.2
plot	JLW29-82	3	1452	5	24.3	31.5368	33.5328	33.5328	33.932	2.8
Lowe, MAXWAV Tests										
plot	JLW29-60	2		5	8.5	106.1872	99.8	85.4288	103.792	18.5
plot	JLW29-64	1		5	8.3	88.6224	105.3888	110.1792	124.9496	18.5
plot	JLW29-68	3		5	8.5	99.4008	103.792	95.0096	93.0136	16.7
plot	JLW29-30	2		4	8.3	109.78	115.3688	118.9616	104.5904	16.1
plot	JLW29-35	3		4	8.2	80.2392	84.6304	89.82	85.828	13.4
plot	JLW29-10	2		3	7.9	75.4488	125.748	79.84	73.852	15.0
plot	JLW29-17	1		3	7.8	90.2192	166.0672	91.0176	108.1832	11.6
plot	JLW29-21	3		3	7.9	69.0616	63.872	78.6424	77.844	14.1
Lowe, 40 hp, MAXPOW Tests										
plot	JLW28-5	1	1140	5	26.2	34.3312	37.924	35.928	43.1136	5.5
plot	JLW28-10	2	1218	5	25.6	35.1296	49.9	42.7144	51.896	5.3
plot	JLW28-14	3	1230	5	25.2	38.7224	44.3112	41.5168	45.5088	3.4
plot	JLW28-20	1	1301	4	25.8	33.932	37.5248	40.7184	42.3152	6.7
plot	JLW28-21	2	1305	4	26.3	35.1296	33.1336	30.7384	32.3352	6.8
plot	JLW28-30	3	1327	4	27.4	28.7424	29.5408	34.3312	26.7464	3.6
plot	JLW28-31	1	1424	3	27.4	27.1456	25.948	25.5488	26.3472	5.9
plot	JLW28-39	2	1443	3	27.7	29.1416	28.7424	25.948	23.952	2.8
plot	JLW28-41	3	1451	3	27.4	23.952	28.3432	31.936	26.7464	3.4
Aleckson, 50 hp, MAXPOW Tests										
plot	JNW28-3	1	957	3	15.0	50.2992	59.88	71.0576	56.2872	11.5
Plot	JNW28-8	2	1018	3	15.0	44.7104	53.4928	52.2952	53.892	12.5
Plot	JNW28-13	3	1041	3	15.1	51.4968	57.4848	53.4928	57.4848	11.3
Plot	JNW28-19	1	1625	1	17.0	39.1216	35.928	22.7544	53.892	8.4
Plot	JNW28-22	2	1658	1	17.2	27.5448	37.1256	31.936	28.7424	9.3
Plot	JNW28-30	3	1722	1	17.3	32.3352	37.1256	27.944	25.1496	13.7
Plot	JNW28-31	1	1728	1	19.5	43.912	39.1216	45.908	57.884	8.6

(Sheet 3 of 3)

Table 32
Kenai River, Energy and Angle

	Test No.	Sail	Time	Load	Speed GPS mph	Energy, ft-lb/ft of wave front Gage 1	Gage 2	Gage 3	Gage 4	Angle, deg
Willie Predator, 35 hp, MAXPOW Tests										
plot	KWP02-3	1/DNS	1530	6	24.9	116	136	132		11
plot	KWP02-25	2/DNS	1743	6	25.0	104	128	164		unc
plot	KWP02-33	3/DNS	1829	6	25.2	140	200	144		unc
plot	KWP02-6	1/UPS	1539	6	16.2	200	299	228		8
plot	KWP02-20	2/UPS	1714	6	15.7	176	295	339		unc
plot	KWP02-40	3/UPS	1900	6	16.3	208	299	415		unc
Willie Predator, MAXWAV Tests										
plot	KWP01-57	1/DNS		6	13.0	116	136	259		34
plot	KWP01-64	1/UPS		6	5.3	866	1593	2196		10
plot	KWP01-81	2/DNS		6	13.1	104	112	196		26
plot	KWP01-78	2/UPS		6	5.1	699	778	1768		9
Willie Predator, 50 hp, MAXPOW Tests										
plot	KWP01-13	1/DNS	1135	6	30.3	128	172	152		8
plot	KWP01-19	2/DNS	1343	6	30.3	68	104	112		unc
plot	KWP01-35	3/DNS	1551	6	29.9	124	144	144		unc
plot	KWP01-4	1/UPS	1103	6	20.6	168	196	176		4
plot	KWP01-22	2/UPS	1352	6	20.5	156	283	251		unc
plot	KWP01-38	3/UPS	1602	6	19.9	208	240	236		unc
Koeffler, 35 hp, MAXPOW Tests										
plot	KKF02-7	1/DNS	1002	6	27.6	56	32	80		12
plot	KKF02-25	2/DNS	1152	6	27.4	72	76	88		unc
plot	KKF02-33	3/DNS	1230	6	27.1	88	80	92		unc
plot	KKF02-14	1/UPS		6	18.0	128	136	200		2
plot	KKF02-26	2/UPS	1156	6	17.7	283	220	204		unc
plot	KKF02-42	3/UPS	1312	6	17.3	176	228	232		unc
Koeffler, MAXWAV Tests										
plot	KKF03-31	1/DNS		6	13.4	144	104	192	160	23
plot	KKF03-2	1/UPS		6	5.0	870	1365	834	679	10
plot	KKF03-49	2/DNS		6	13.2	44	96	84	88	20
plot	KKF03-46	2/UPS		6	5.2	655	986	846	1134	12
Koeffler, 50 hp, MAXPOW Tests										
plot	KKF03-51	1/DNS		6	28.9	76	88	112	76	7
plot	KKF03-77	2/DNS		6	29.5	56	64	120	57	unc
plot	KKF03-93	3/DNS		6	29.4	52	96	96	124	unc
plot	KKF03-56	1/UPS		6	21.3	100	120	100	164	0
plot	KKF03-80	2/UPS		6	21.0	144	184	164	108	unc
plot	KKF03-90	3/UPS		6	21.5	72	92	140	160	unc

Note: unc = uncertain angle.

Table 33
Summary of Wave Energy and Angle at Johnson Lake

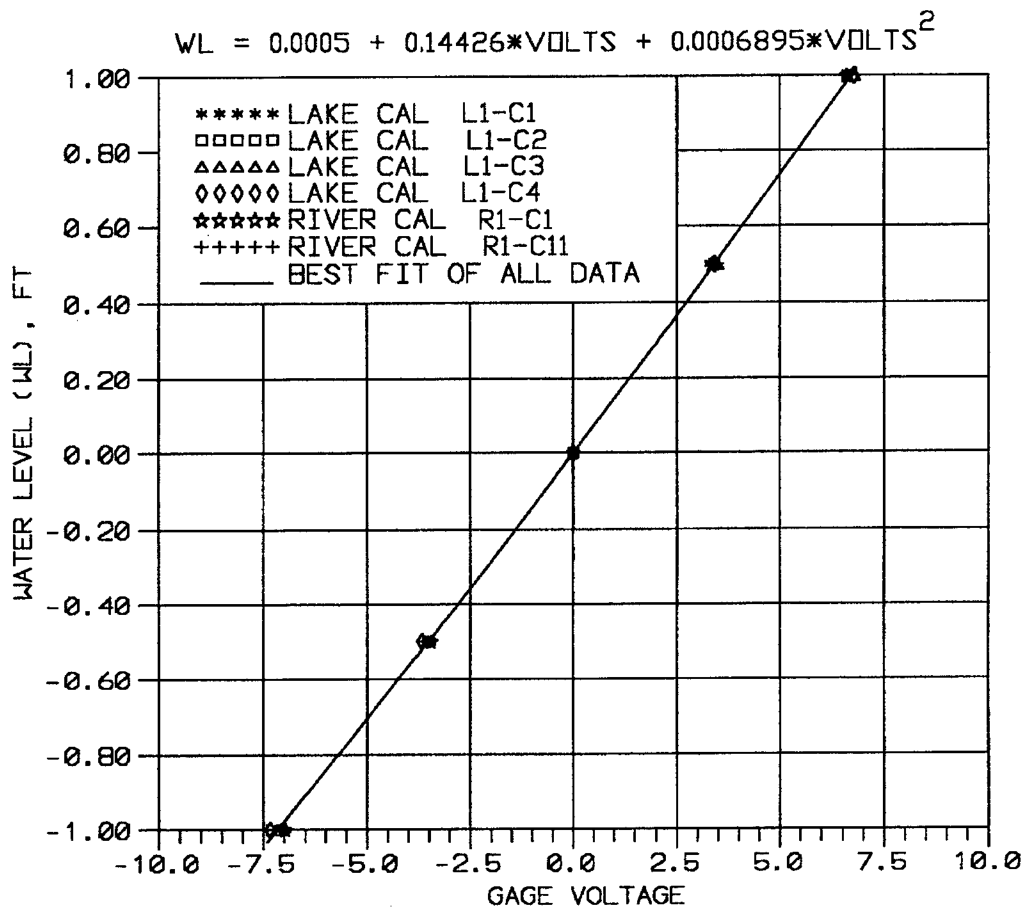
Location/boat/motor	Wave type	Average wave train energy for all sailing lines and all loadings, ft-lbs/ft of wave front	Average angle, deg
JWP35	MAXPOW	133	9
JWP35-6 passengers	MAXPOW	177	13
JWP50	MAXPOW	79	5
JWP50-6 passengers	MAXPOW	98	5
JKF35	MAXPOW	59	6
JKF35-6 passengers	MAXPOW	73	6
JKF50	MAXPOW	44	5
JKF50-6 passengers	MAXPOW	53	4
JKL35	MAXPOW	57	6
JKL40	MAXPOW	49	5
JLW35	MAXPOW	30	5
JLW40	MAXPOW	34	5
JNW50	MAXPOW	44	11
JWP	MAXWAV	151	14
JWP-6 passengers	MAXWAV	163	11
JKF	MAXWAV	86	17
JKF-6 passengers	MAXWAV	81	21
JKL	MAXWAV	111	18
JLW	MAXWAV	97	15

Table 34
Summary of Wave Energy and Angle at Kenai River (Six Passengers)

Location/boat/motor	Wave type	Average wave train energy for all sailing lines, ft-lbs/ft of wave front	Average angle, deg
KWP35-DOWN	MAXPOW	140	11
KWP35-UP	MAXPOW	273	8
KWP50-DOWN	MAXPOW	127	8
KWP50-UP	MAXPOW	212	4
KKF35-DOWN	MAXPOW	74	12
KKF35-UP	MAXPOW	200	2
KKF50-DOWN	MAXPOW	85	7
KKF50-UP	MAXPOW	129	0
KWP-DOWN	MAXWAV	154	30
KWP-UP	MAXWAV	1317	10
KKF-DOWN	MAXWAV	114	22
KKF-UP	MAXWAV	921	11

Table 35
Comparison of MAXPOW for WP and KF for Six Loads Only, Averaged Over All Distances and Upstream and Downstream Averaged on the Kenai River

Boat	MAXPOW, ft			
	Lake, 35 hp	Lake, 50 hp	River, 35 hp	River, 50 hp
WP	0.683	0.572	0.611	0.536
KF	0.413	0.351	0.394	0.387



GAGE 1 CALIBRATION, ALL TESTS

Plate 1

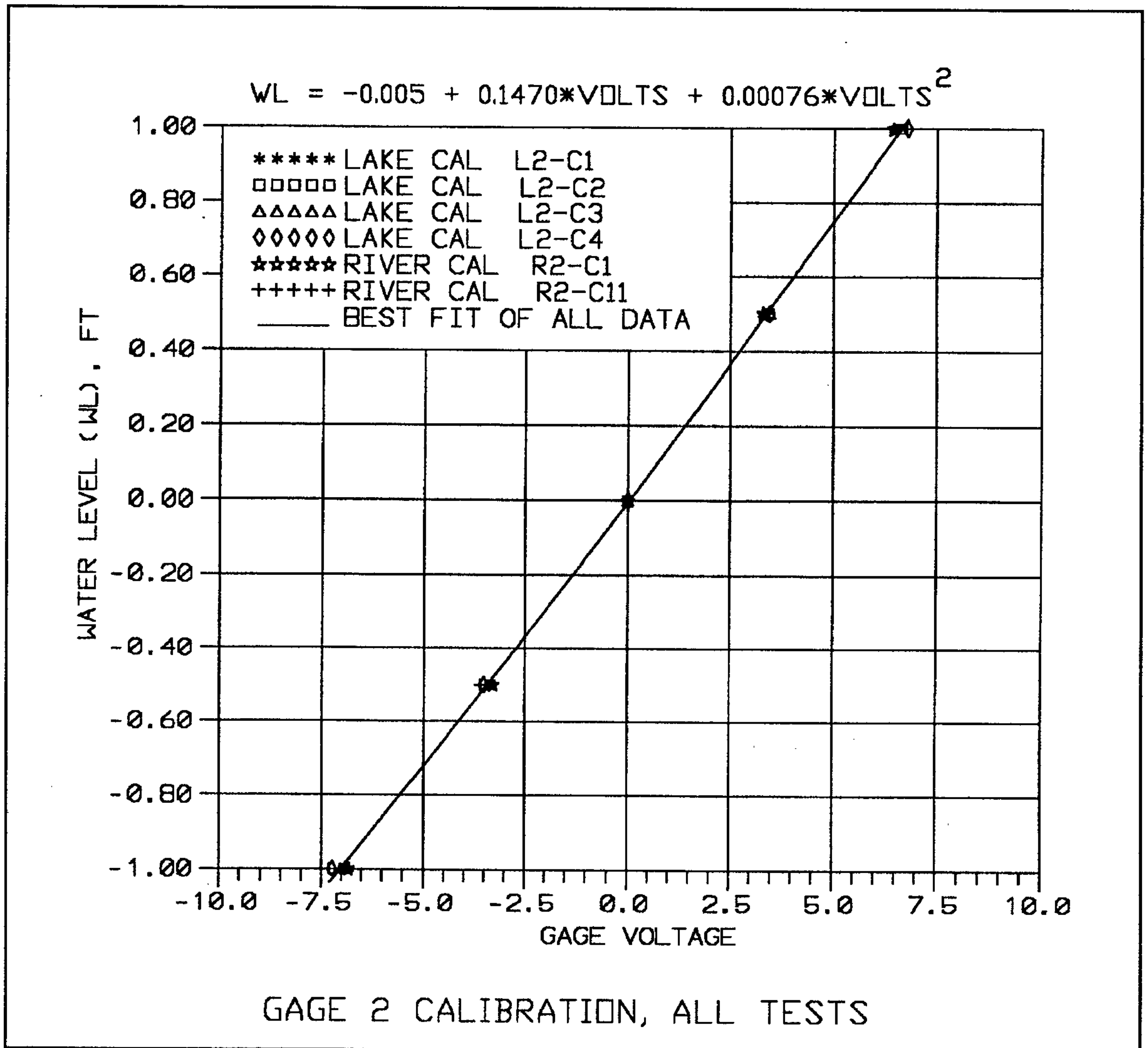

WL = -0.005 + 0.1470*VOLTS + 0.00076*VOLTS²
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
WATER LEVEL (WL), FT
***** LAKE CAL L2-C1
□□□□□ LAKE CAL L2-C2
△△△△△ LAKE CAL L2-C3
◇◇◇◇◇ LAKE CAL L2-C4
☆☆☆☆☆ RIVER CAL R2-C1
+++++ RIVER CAL R2-C11
—— BEST FIT OF ALL DATA
-10.0
-7.5
-5.0
-2.5
0.0
2.5
5.0
7.5
10.0
GAGE VOLTAGE
GAGE 2 CALIBRATION, ALL TESTS

Plate 2

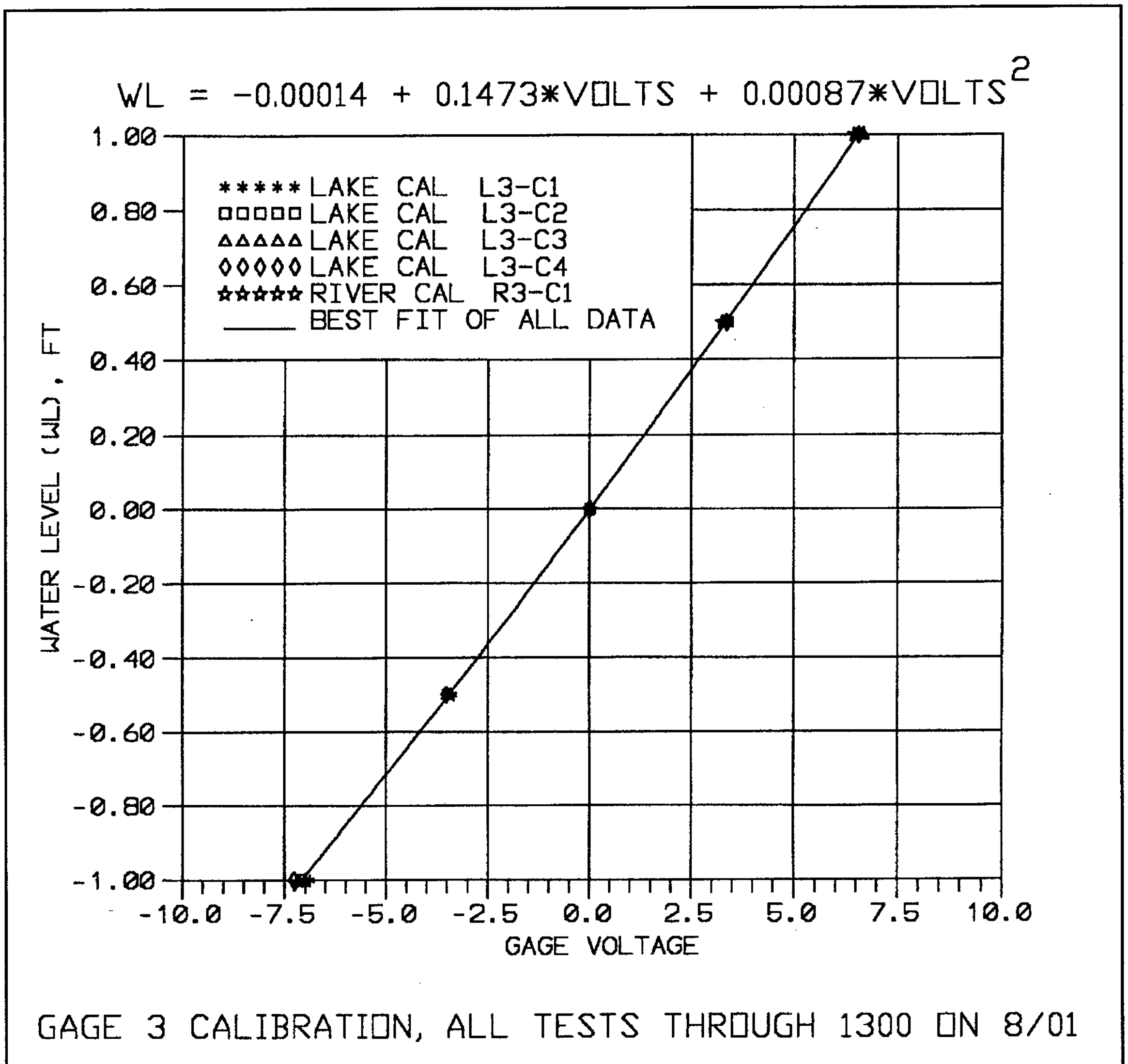

WL = -0.00014 + 0.1473*VOLTS + 0.00087*VOLTS^2
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
WATER LEVEL (WL), FT
***** LAKE CAL L3-C1
□□□□□ LAKE CAL L3-C2
△△△△△ LAKE CAL L3-C3
◇◇◇◇◇ LAKE CAL L3-C4
☆☆☆☆☆ RIVER CAL R3-C1
BEST FIT OF ALL DATA
-10.0
-7.5
-5.0
-2.5
0.0
2.5
5.0
7.5
10.0
GAGE VOLTAGE
GAGE 3 CALIBRATION, ALL TESTS THROUGH 1300 ON 8/01

Plate 3

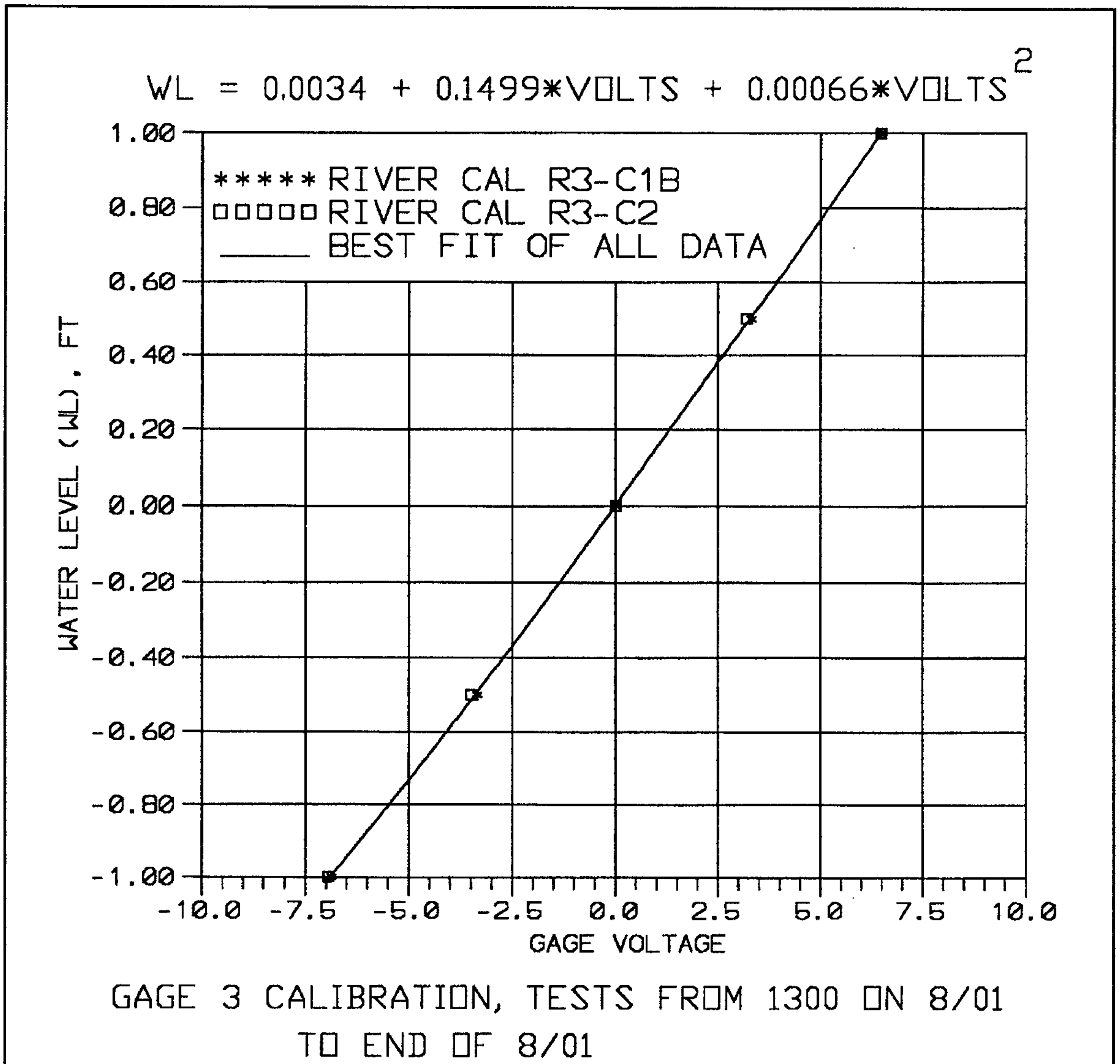
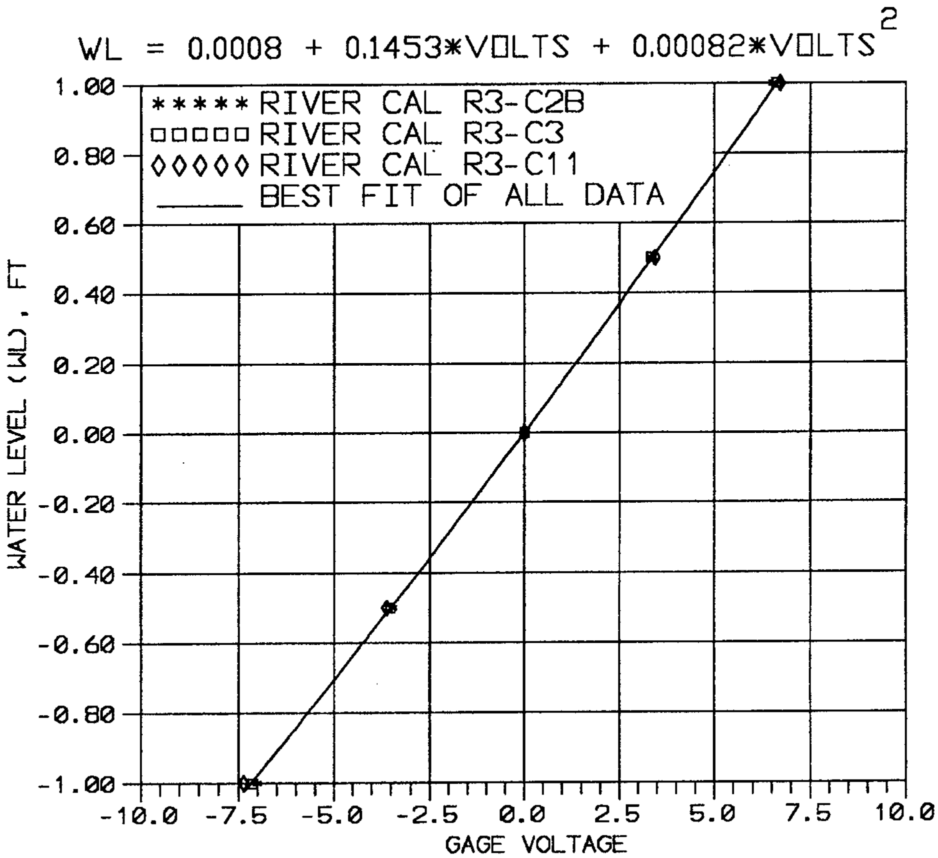
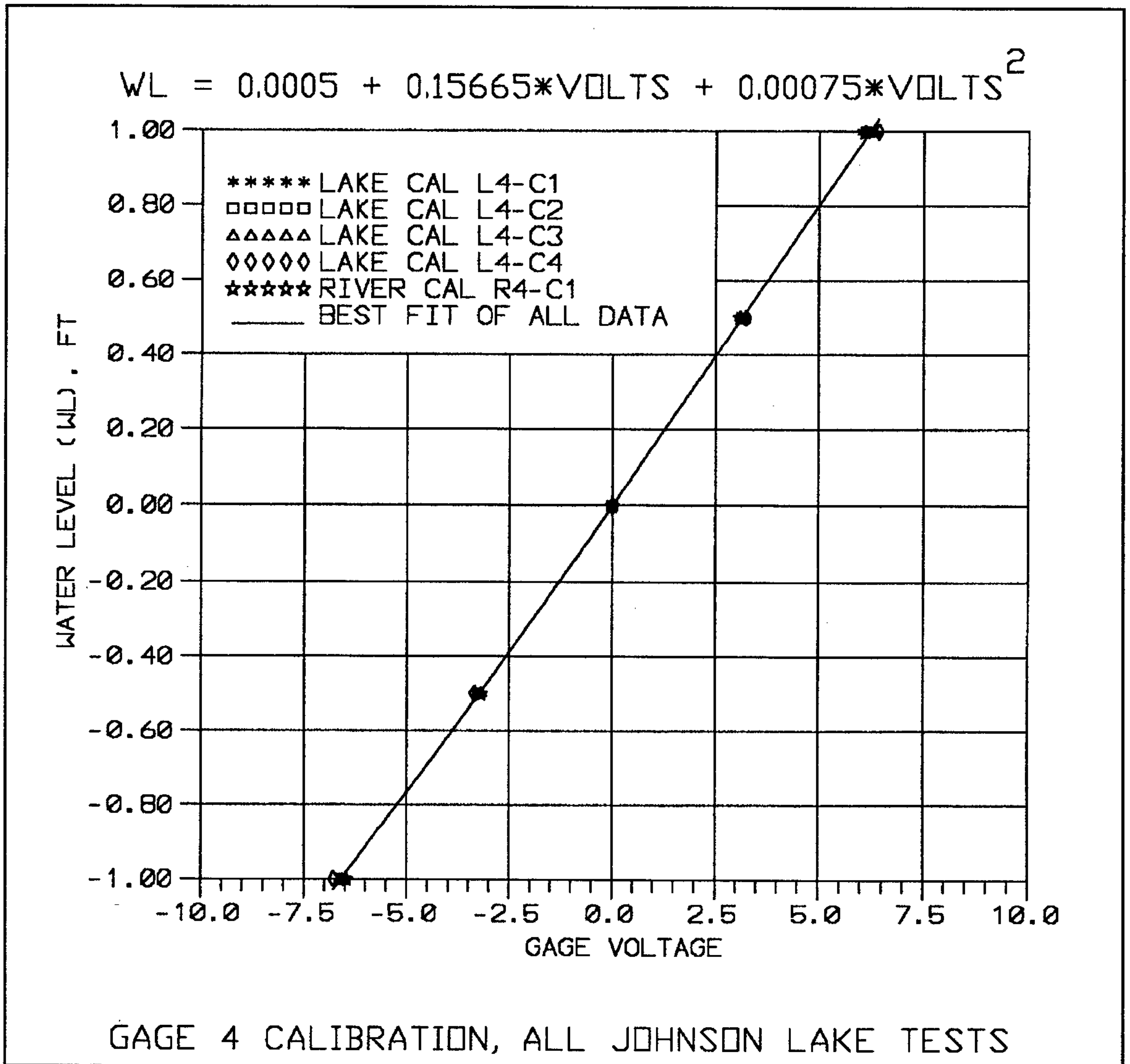

WL = 0.0034 + 0.1499*VOLTS + 0.00066*VOLTS 2
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
WATER LEVEL (WL), FT
*****RIVER CAL R3-C1B
□□□□□RIVER CAL R3-C2
BEST FIT OF ALL DATA
-10.0
-7.5
-5.0
-2.5
0.0
2.5
5.0
7.5
10.0
GAGE VOLTAGE
GAGE 3 CALIBRATION, TESTS FROM 1300 ON 8/01
TO END OF 8/01

Plate 4



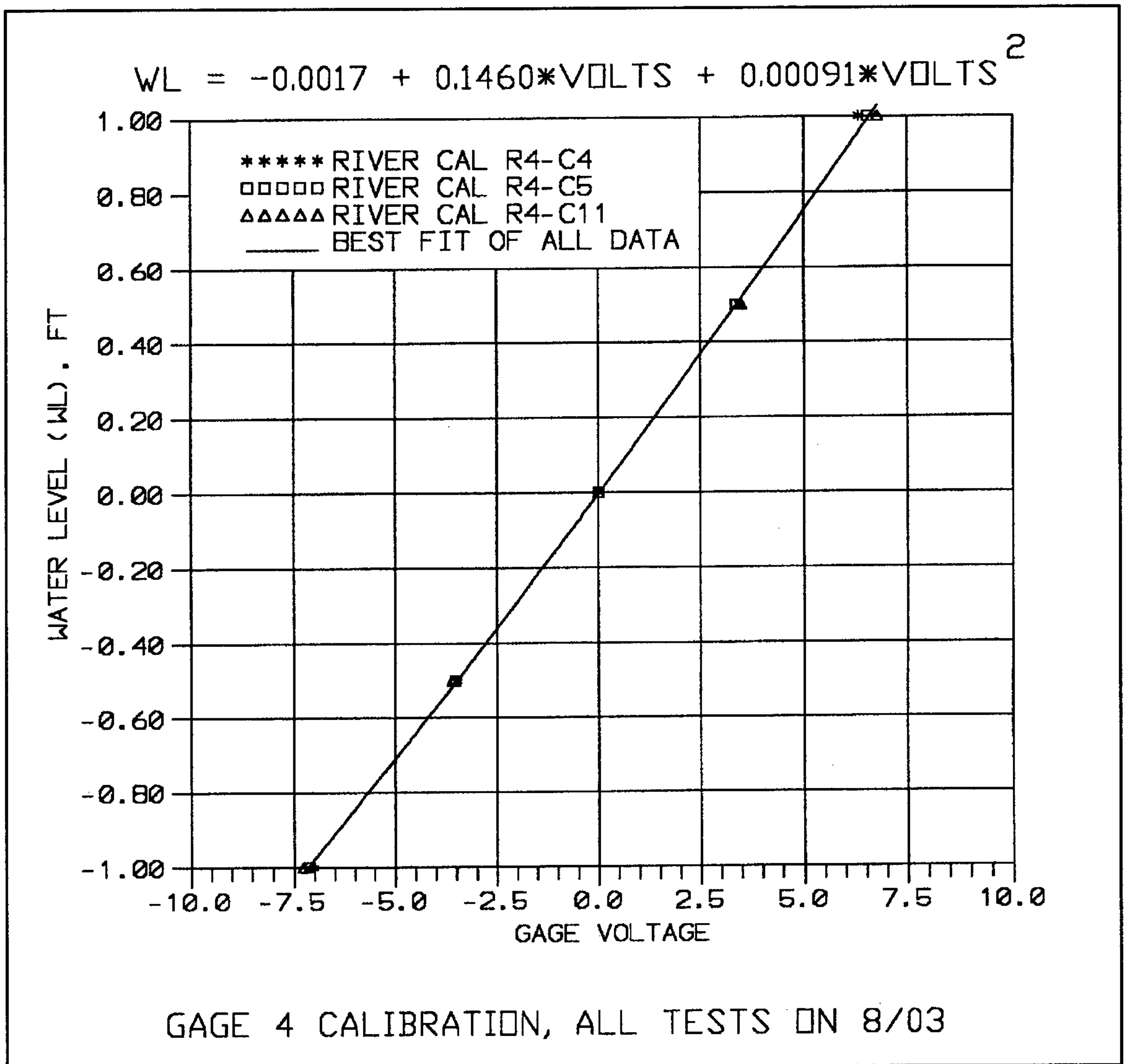
GAGE 3 CALIBRATION, TESTS FROM BEGINNING OF 8/02 TO END OF ALL TESTING ON 8/03

Plate 5



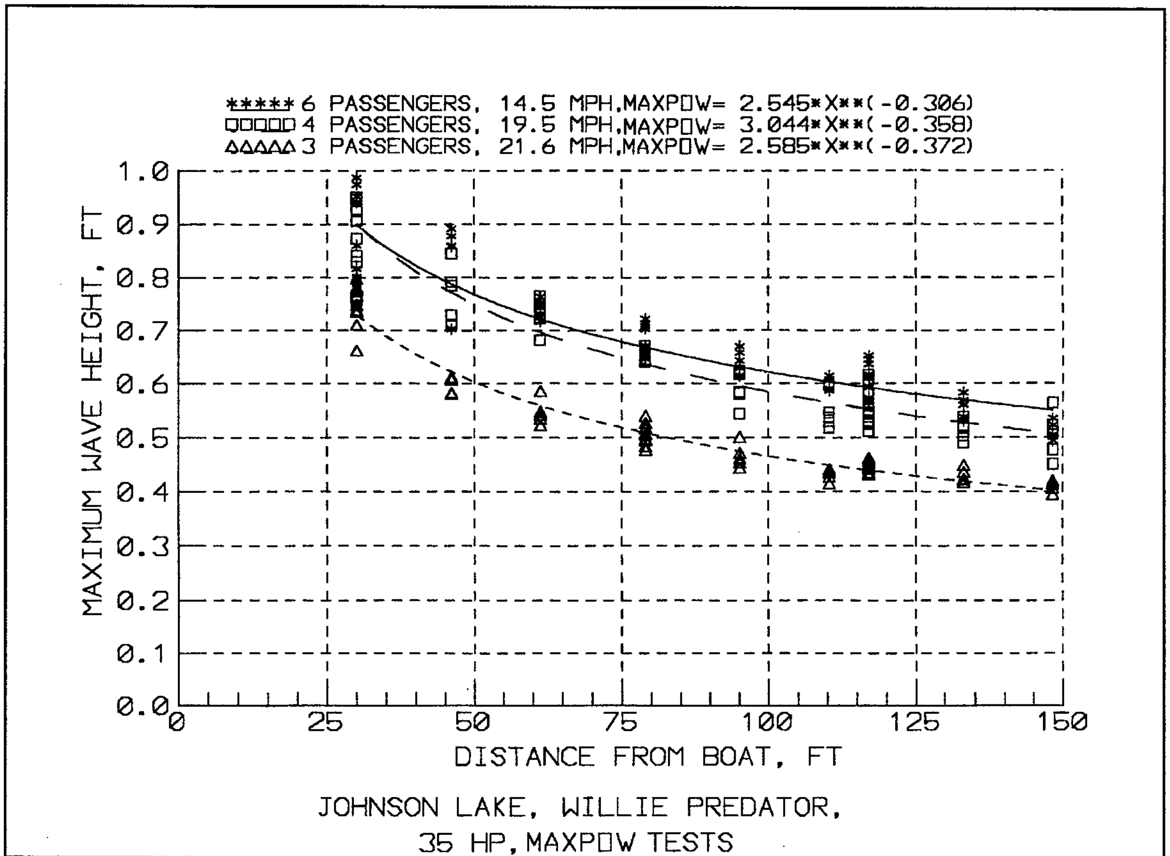
WL = 0.0005 + 0.15665*VOLTS + 0.00075*VOLTS^2
*****LAKE CAL L4-C1
□□□□□LAKE CAL L4-C2
△△△△△LAKE CAL L4-C3
◊◊◊◊◊LAKE CAL L4-C4
☆☆☆☆☆RIVER CAL R4-C1
BEST FIT OF ALL DATA
WATER LEVEL (WL), FT
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-10.0
-7.5
-5.0
-2.5
0.0
2.5
5.0
7.5
10.0
GAGE VOLTAGE
GAGE 4 CALIBRATION, ALL JOHNSON LAKE TESTS

Plate 6



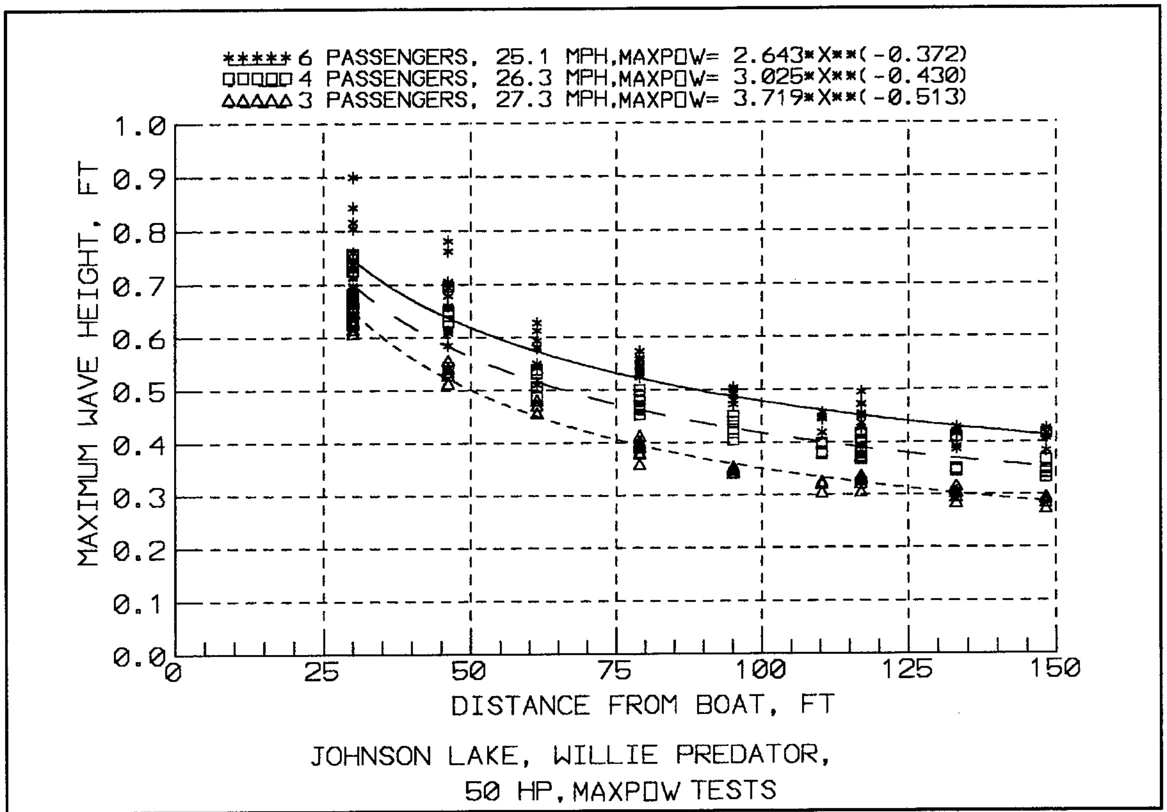
WL = -0.0017 + 0.1460*VOLTS + 0.00091*VOLTS 2
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
WATER LEVEL (WL), FT
***** RIVER CAL R4-C4
□□□□□ RIVER CAL R4-C5
△△△△△ RIVER CAL R4-C11
BEST FIT OF ALL DATA
-10.0
-7.5
-5.0
-2.5
0.0
2.5
5.0
7.5
10.0
GAGE VOLTAGE
GAGE 4 CALIBRATION, ALL TESTS ON 8/03

Plate 7



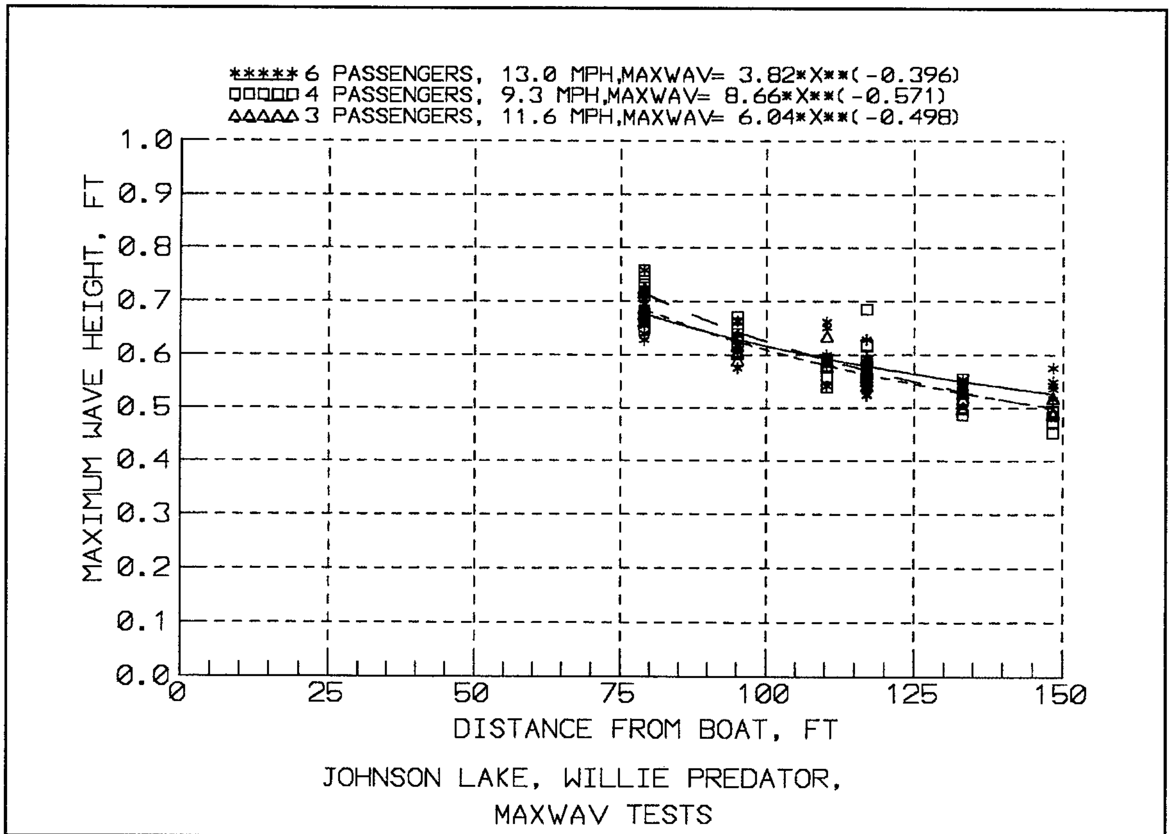
*****6 PASSENGERS, 14.5 MPH,MAXPOW= 2.545*X**(-0.306)
□□□□□4 PASSENGERS, 19.5 MPH,MAXPOW= 3.044*X**(-0.358)
ΔΔΔΔΔ3 PASSENGERS, 21.6 MPH,MAXPOW= 2.585*X**(-0.372)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, WILLIE PREDATOR,
35 HP, MAXPOW TESTS

Plate 8



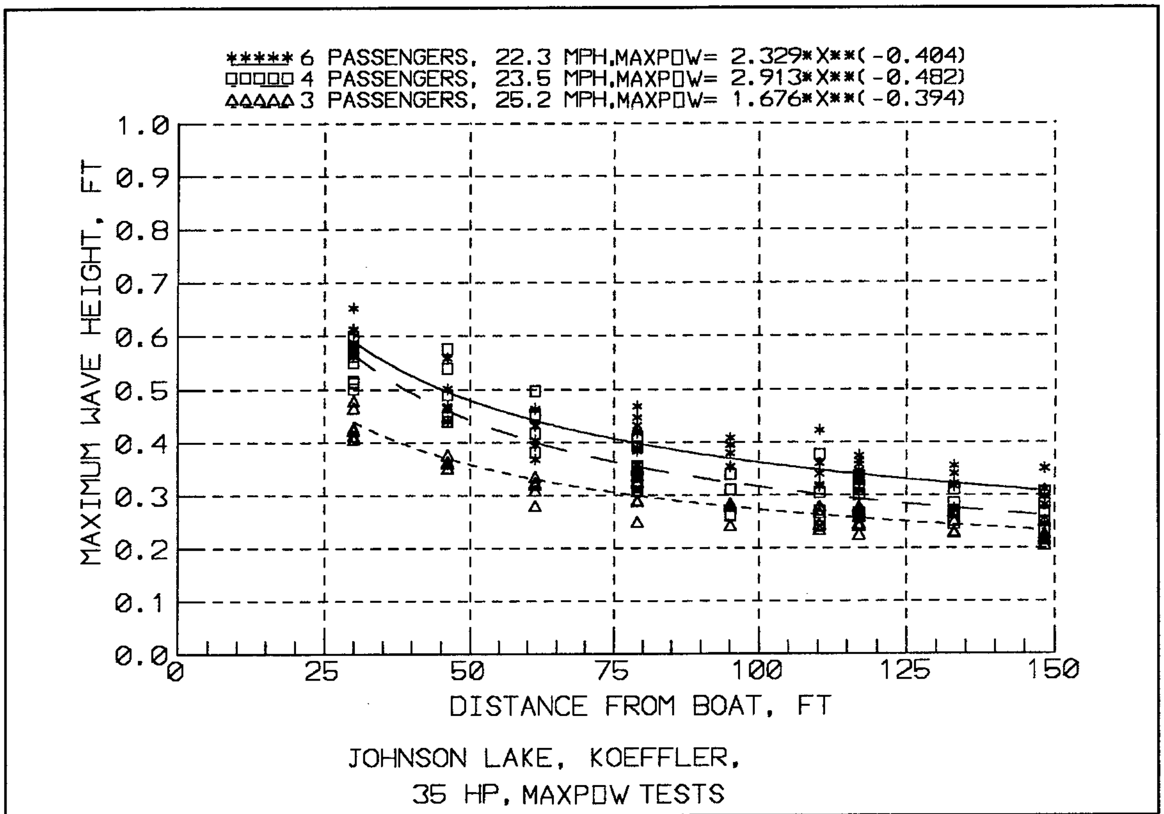
*****6 PASSENGERS, 25.1 MPH,MAXPOW= 2.643*X**(-0.372)
□□□□□4 PASSENGERS, 26.3 MPH,MAXPOW= 3.025*X**(-0.430)
ΔΔΔΔΔ3 PASSENGERS, 27.3 MPH,MAXPOW= 3.719*X**(-0.513)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, WILLIE PREDATOR,
50 HP, MAXPOW TESTS

Plate 9



*****6 PASSENGERS, 13.0 MPH,MAXWAV= 3.82*X**(-0.396)
□□□□□4 PASSENGERS, 9.3 MPH,MAXWAV= 8.66*X**(-0.571)
△△△△△3 PASSENGERS, 11.6 MPH,MAXWAV= 6.04*X**(-0.498)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, WILLIE PREDATOR,
MAXWAV TESTS

Plate 10



*****6 PASSENGERS, 22.3 MPH,MAXPOW= 2.329*X**(-0.404)
□□□□□4 PASSENGERS, 23.5 MPH,MAXPOW= 2.913*X**(-0.482)
ΔΔΔΔΔ3 PASSENGERS, 25.2 MPH,MAXPOW= 1.676*X**(-0.394)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
MAXIMUM WAVE HEIGHT, FT
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, KOEFFLER,
35 HP, MAXPOW TESTS

Plate 11

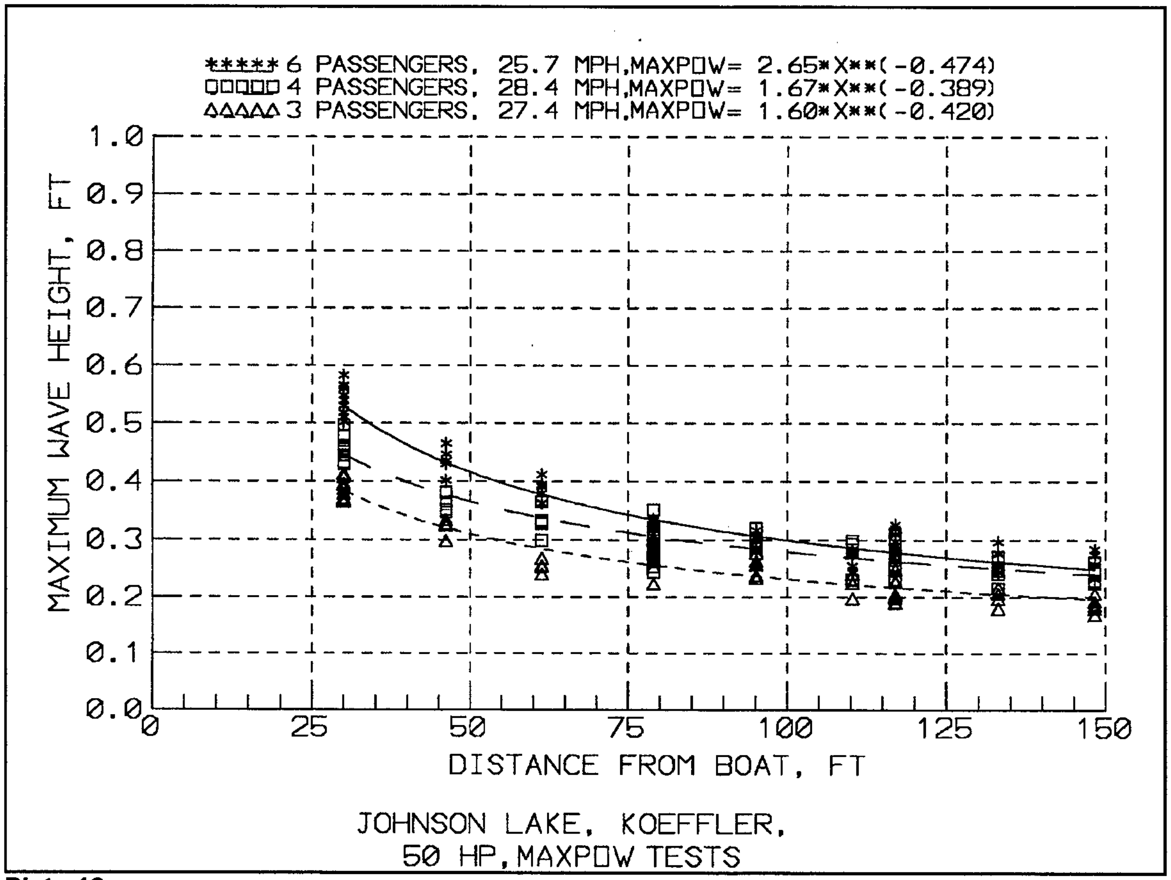
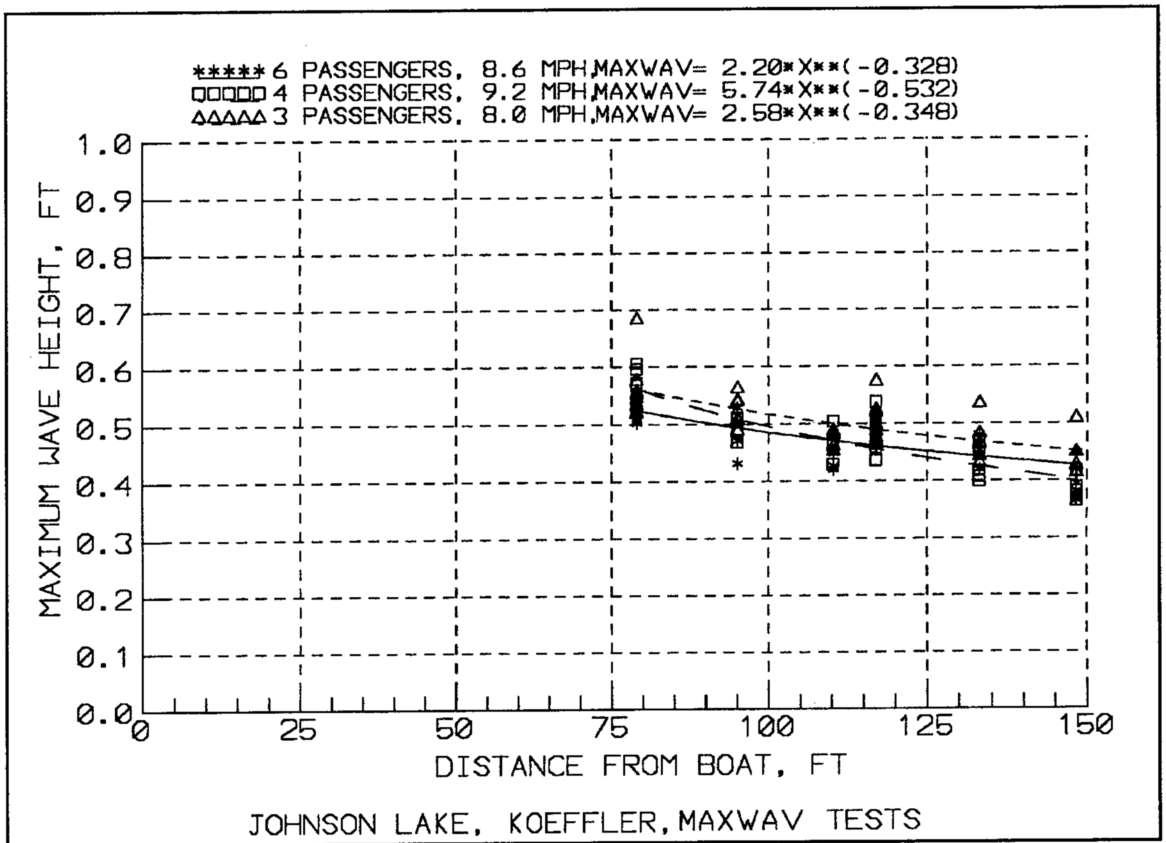
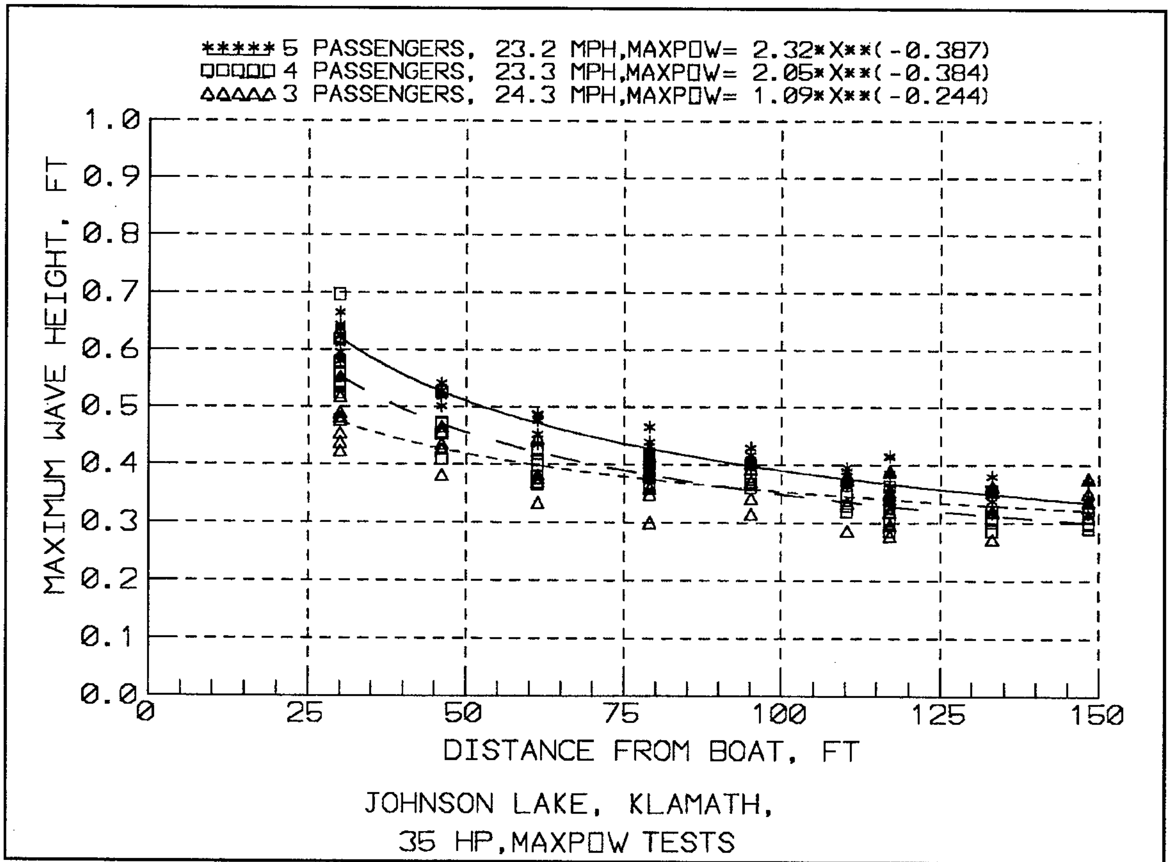

*****6 PASSENGERS, 25.7 MPH,MAXPOW= 2.65*X**(-0.474)
□□□□□4 PASSENGERS, 28.4 MPH,MAXPOW= 1.67*X**(-0.389)
△△△△△3 PASSENGERS, 27.4 MPH,MAXPOW= 1.60*X**(-0.420)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, KOEFFLER,
50 HP, MAXPOW TESTS

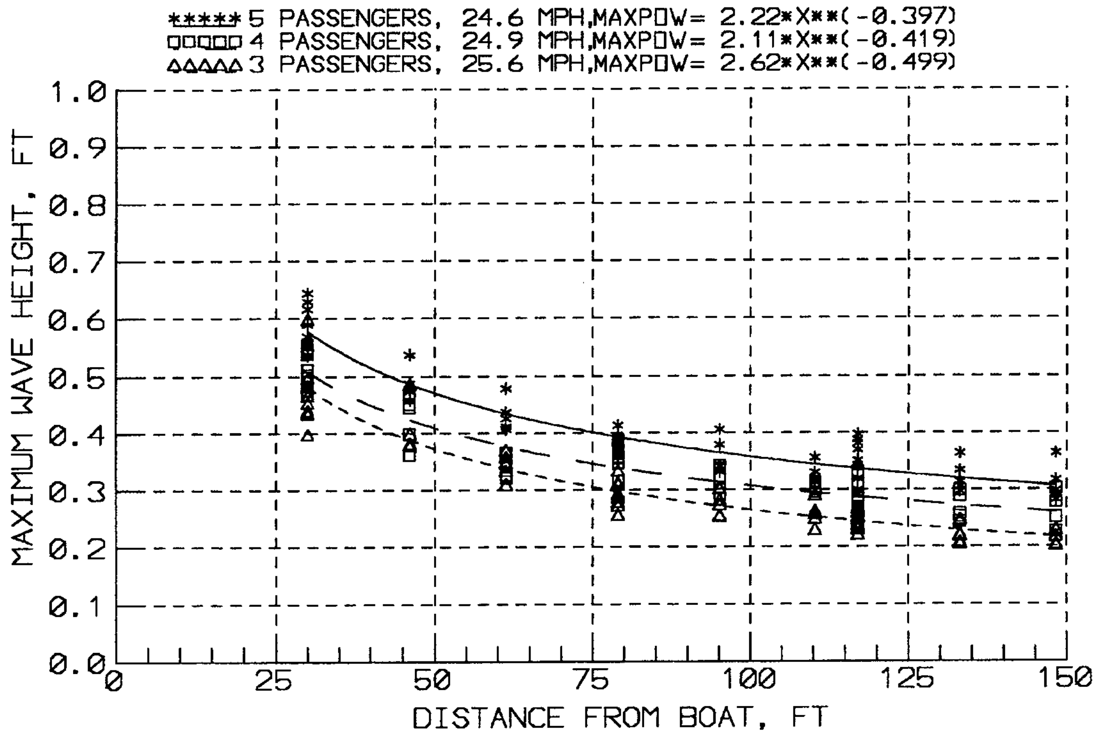
Plate 12



***** 6 PASSENGERS, 8.6 MPH,MAXWAV= 2.20*X**(-0.328)
□□□□□ 4 PASSENGERS, 9.2 MPH,MAXWAV= 5.74*X**(-0.532)
ΔΔΔΔΔ 3 PASSENGERS, 8.0 MPH,MAXWAV= 2.58*X**(-0.348)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, KOEFFLER,MAXWAV TESTS

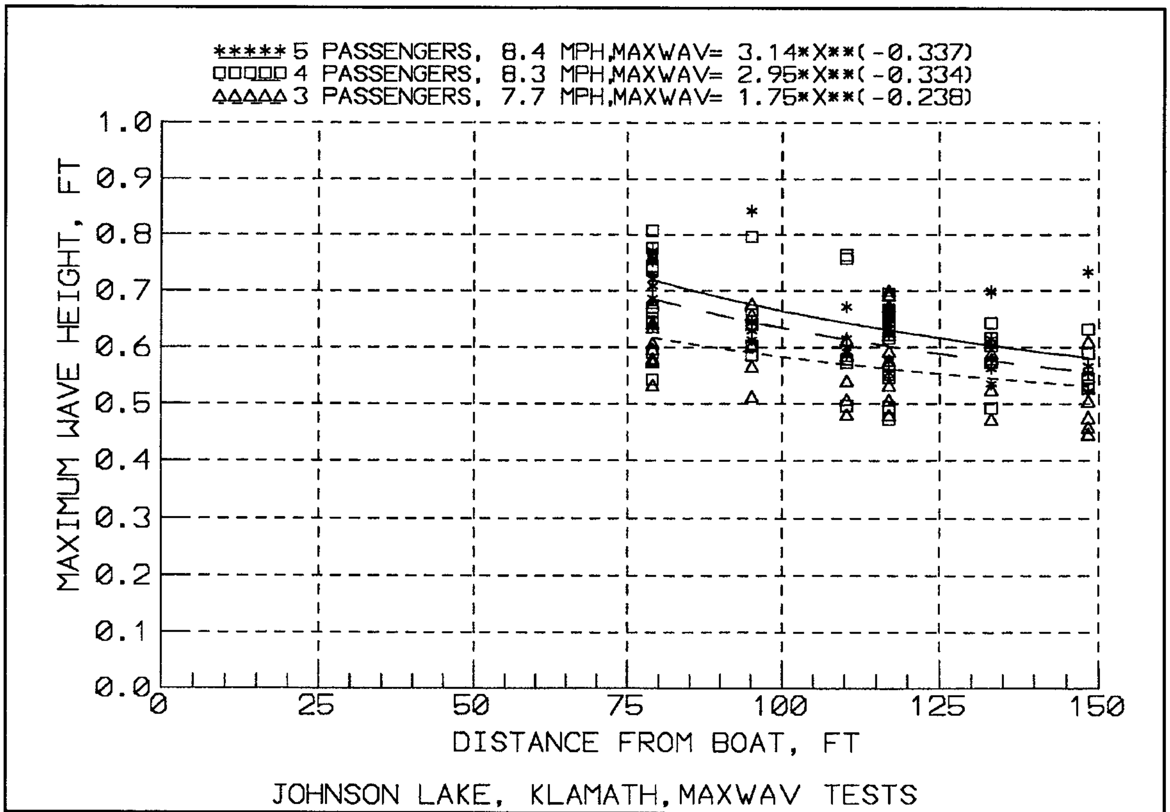
Plate 13


*****5 PASSENGERS, 23.2 MPH,MAXPOW= 2.32*X**(-0.387)
□□□□□4 PASSENGERS, 23.3 MPH,MAXPOW= 2.05*X**(-0.384)
ΔΔΔΔΔ3 PASSENGERS, 24.3 MPH,MAXPOW= 1.09*X**(-0.244)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, KLAMATH,
35 HP,MAXPOW TESTS
Plate 14



JOHNSON LAKE, KLAMATH,
40 HP,MAXPOW TESTS

Plate 15



***** 5 PASSENGERS, 8.4 MPH,MAXWAV= 3.14*X**(-0.337)
□□□□□ 4 PASSENGERS, 8.3 MPH,MAXWAV= 2.95*X**(-0.334)
△△△△△ 3 PASSENGERS, 7.7 MPH,MAXWAV= 1.75*X**(-0.238)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, KLAMATH, MAXWAV TESTS

Plate 16

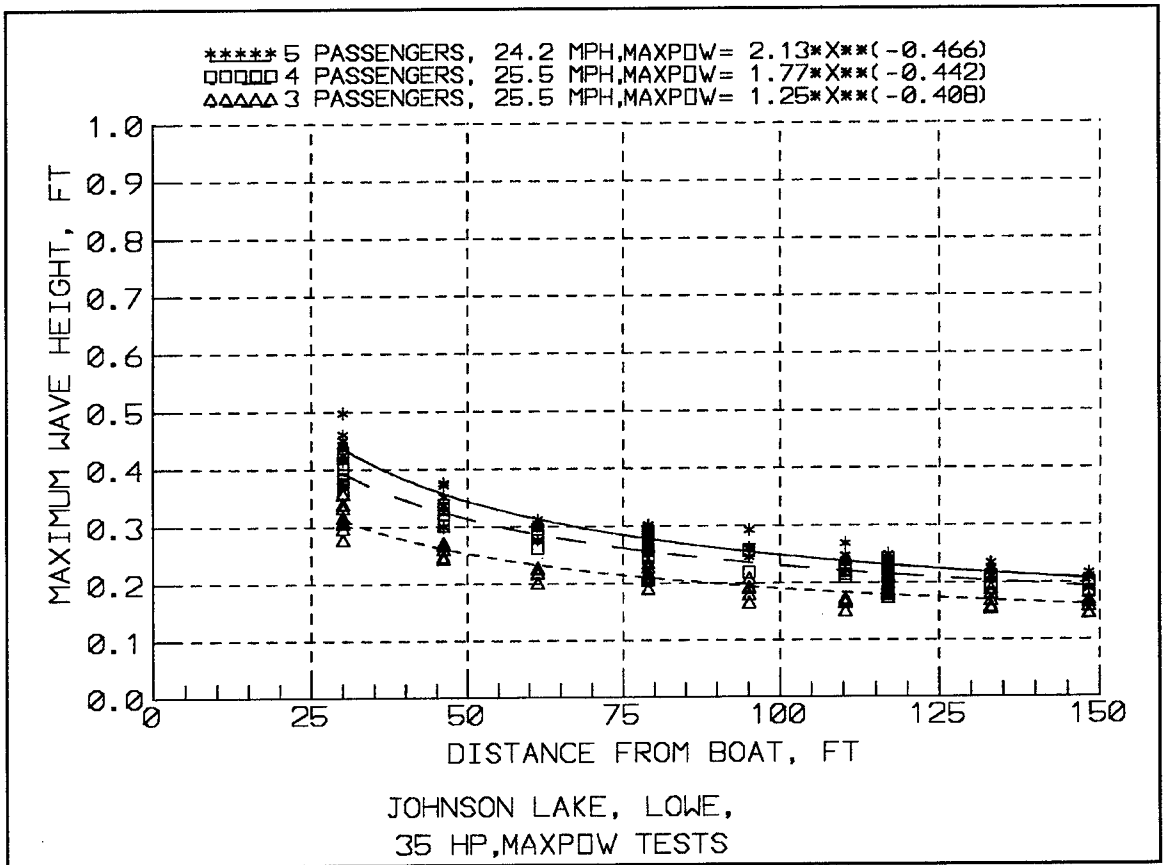
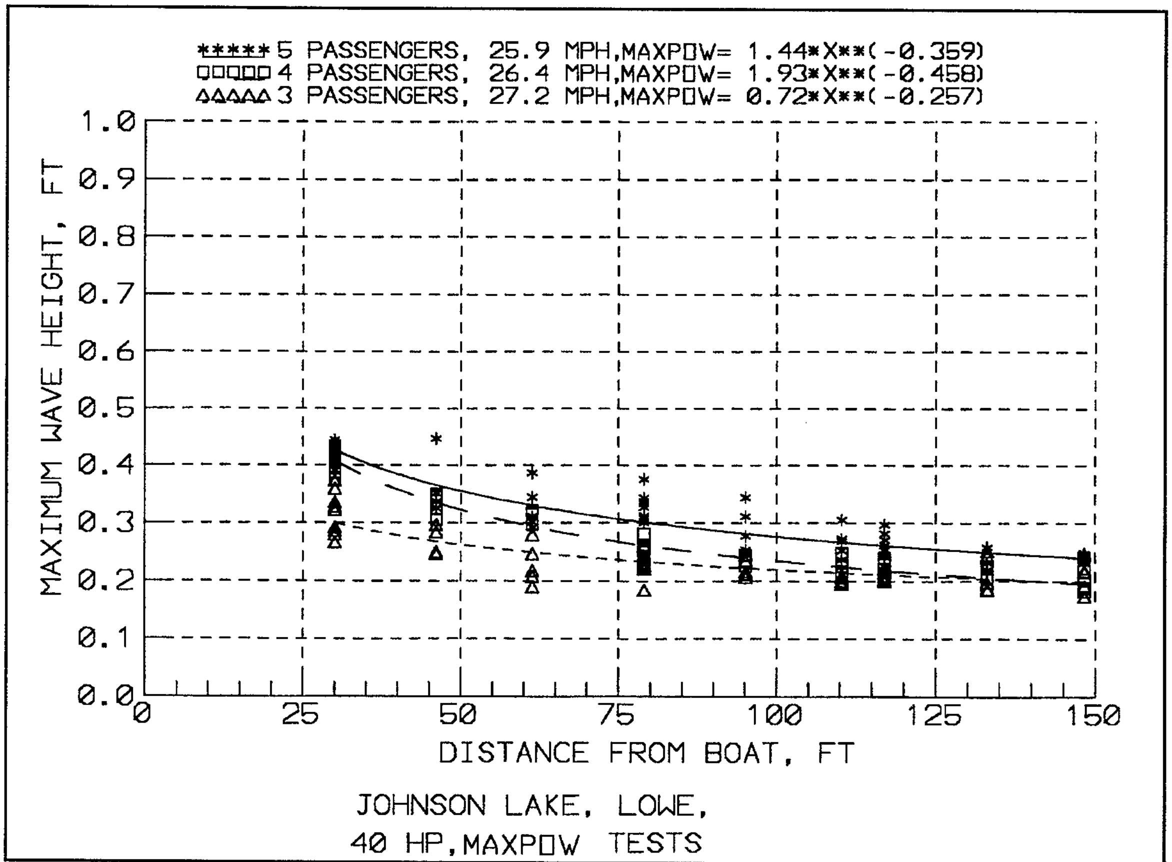

*****5 PASSENGERS, 24.2 MPH,MAXPOW= 2.13*X**(-0.466)
□□□□□4 PASSENGERS, 25.5 MPH,MAXPOW= 1.77*X**(-0.442)
△△△△△3 PASSENGERS, 25.5 MPH,MAXPOW= 1.25*X**(-0.408)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, LOWE,
35 HP,MAXPOW TESTS

Plate 17



*****5 PASSENGERS, 25.9 MPH,MAXPOW= 1.44*X**(-0.359)
□□□□□4 PASSENGERS, 26.4 MPH,MAXPOW= 1.93*X**(-0.458)
ΔΔΔΔΔ3 PASSENGERS, 27.2 MPH,MAXPOW= 0.72*X**(-0.257)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, LOWE,
40 HP,MAXPOW TESTS

Plate 18

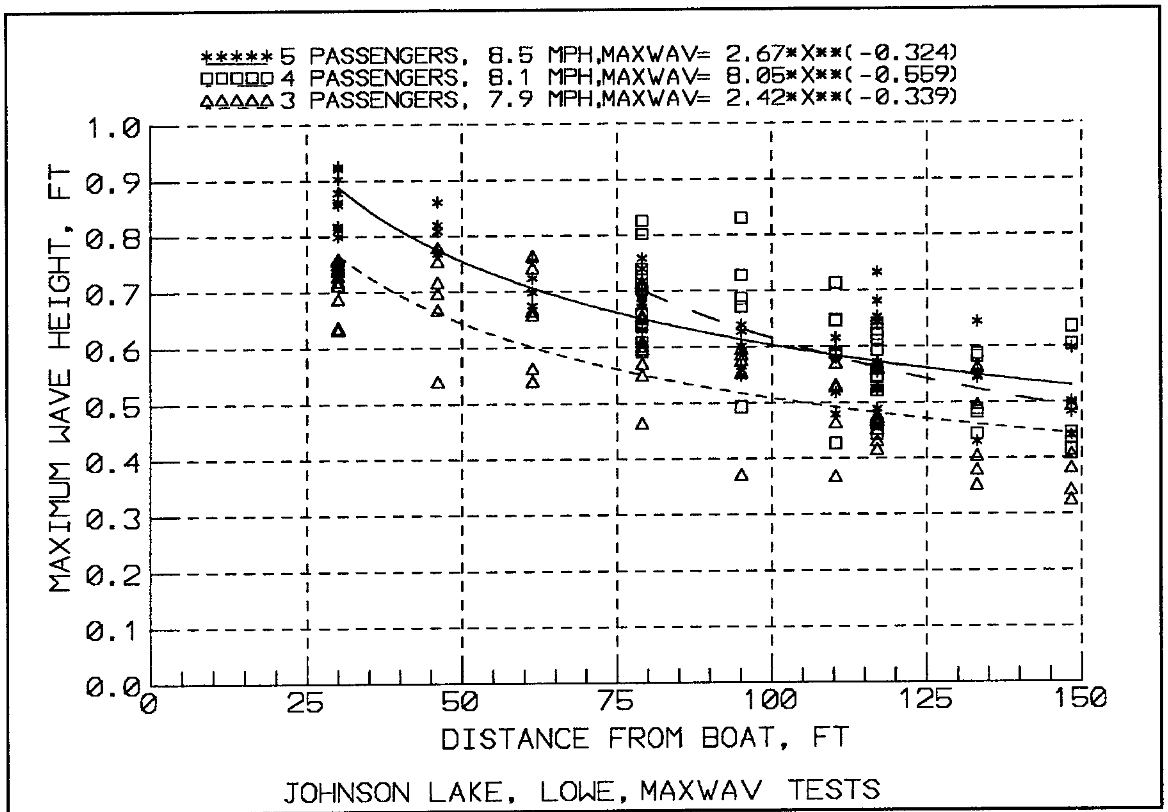
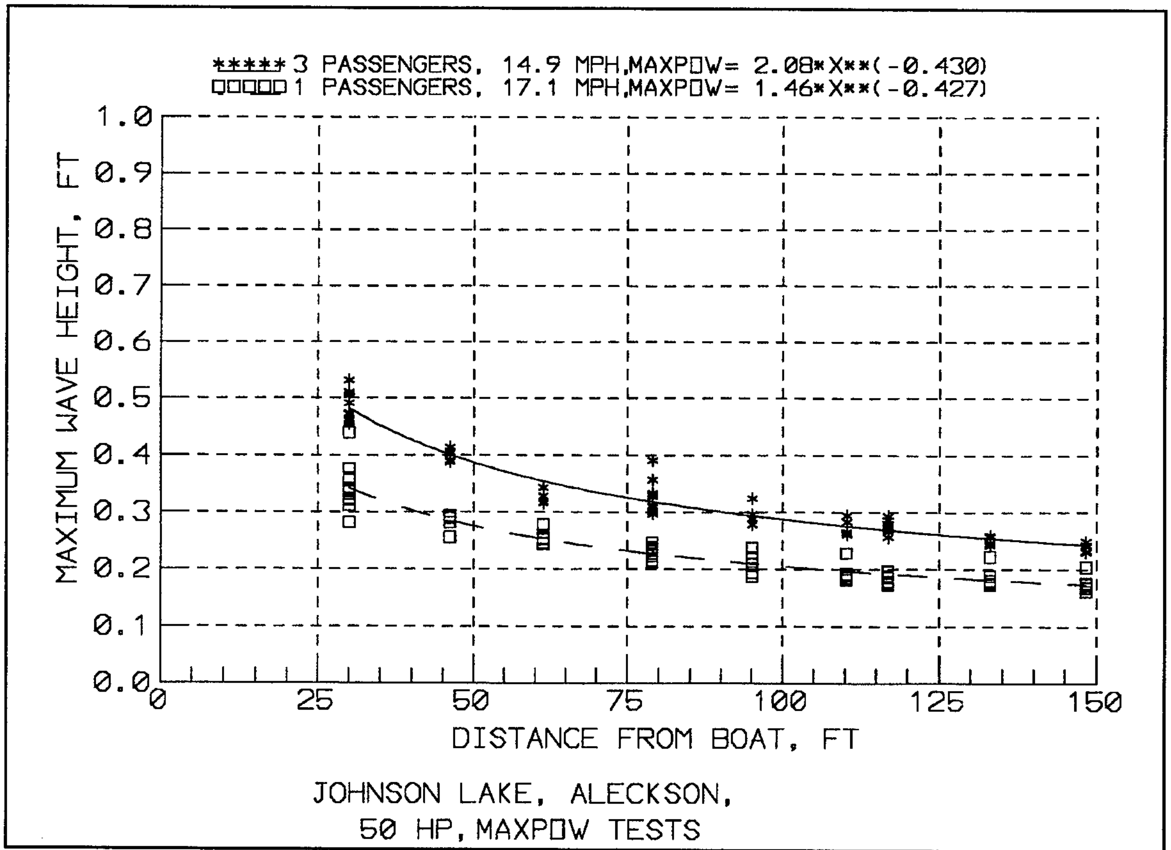
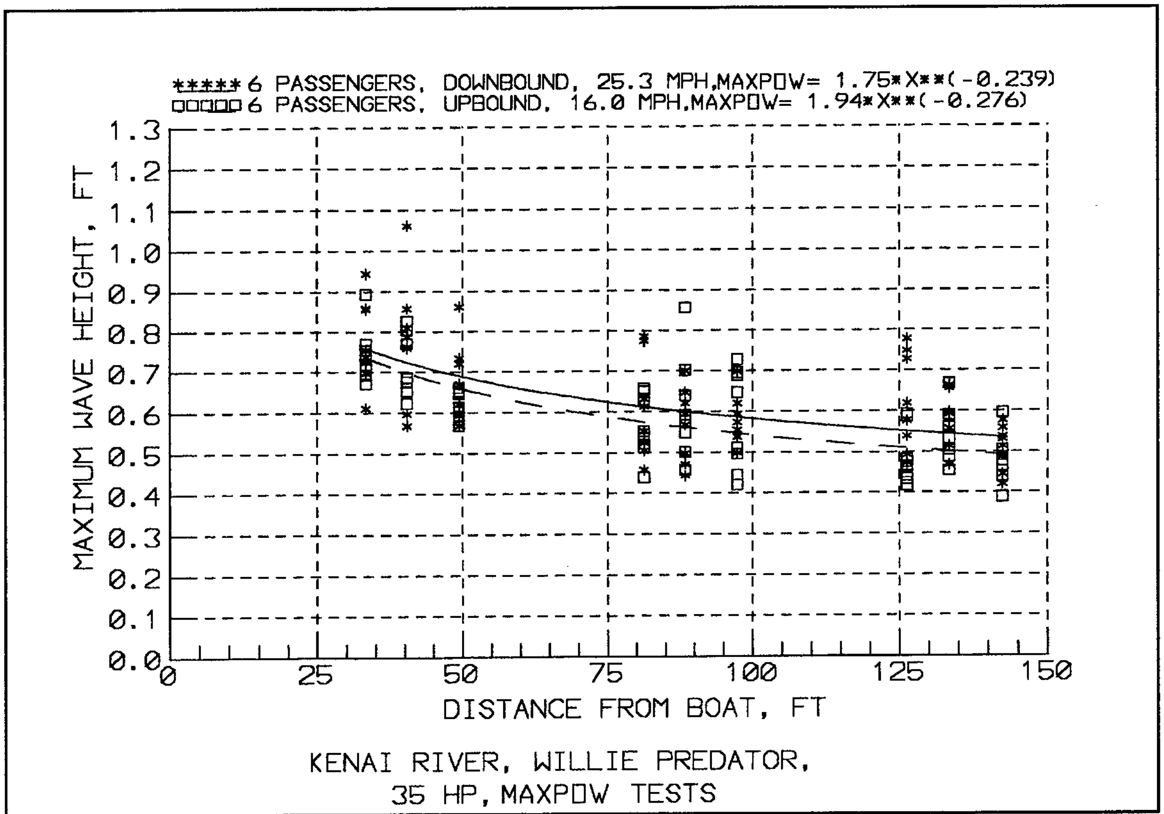

*****5 PASSENGERS, 8.5 MPH,MAXWAV= 2.67*X**(-0.324)
□□□□□4 PASSENGERS, 8.1 MPH,MAXWAV= 8.05*X**(-0.559)
ΔΔΔΔΔ3 PASSENGERS, 7.9 MPH,MAXWAV= 2.42*X**(-0.339)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, LOWE, MAXWAV TESTS

Plate 19



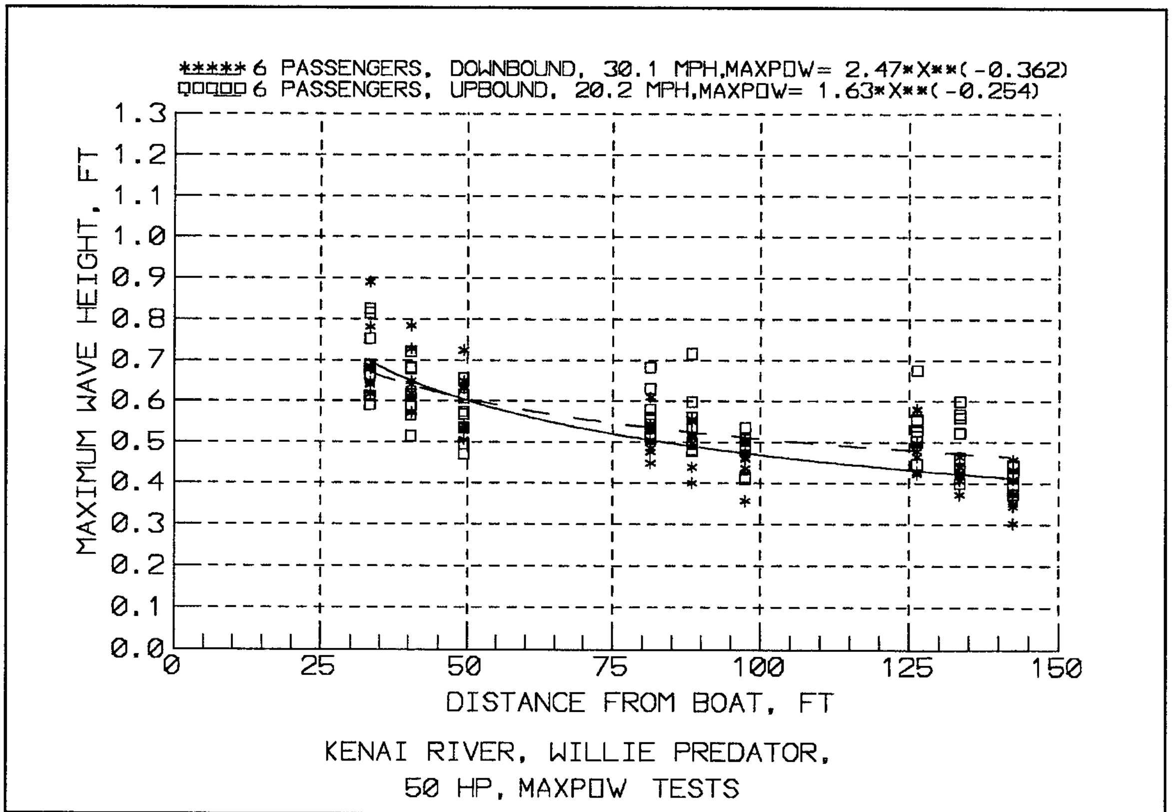
*****3 PASSENGERS, 14.9 MPH,MAXPOW= 2.08*X**(-0.430)
□□□□□1 PASSENGERS, 17.1 MPH,MAXPOW= 1.46*X**(-0.427)
MAXIMUM WAVE HEIGHT, FT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
JOHNSON LAKE, ALECKSON,
50 HP, MAXPOW TESTS

Plate 20



*****6 PASSENGERS, DOWNBOUND, 25.3 MPH,MAXPOW= 1.75*X**(-0.239)
□□□□□6 PASSENGERS, UPBOUND, 16.0 MPH,MAXPOW= 1.94*X**(-0.276)
MAXIMUM WAVE HEIGHT, FT
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
KENAI RIVER, WILLIE PREDATOR,
35 HP, MAXPOW TESTS

Plate 21



*****6 PASSENGERS, DOWNBOUND, 30.1 MPH,MAXPOW= 2.47*X**(-0.362)
□□□□□6 PASSENGERS, UPBOUND, 20.2 MPH,MAXPOW= 1.63*X**(-0.254)
MAXIMUM WAVE HEIGHT, FT
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
KENAI RIVER, WILLIE PREDATOR,
50 HP, MAXPOW TESTS

Plate 22

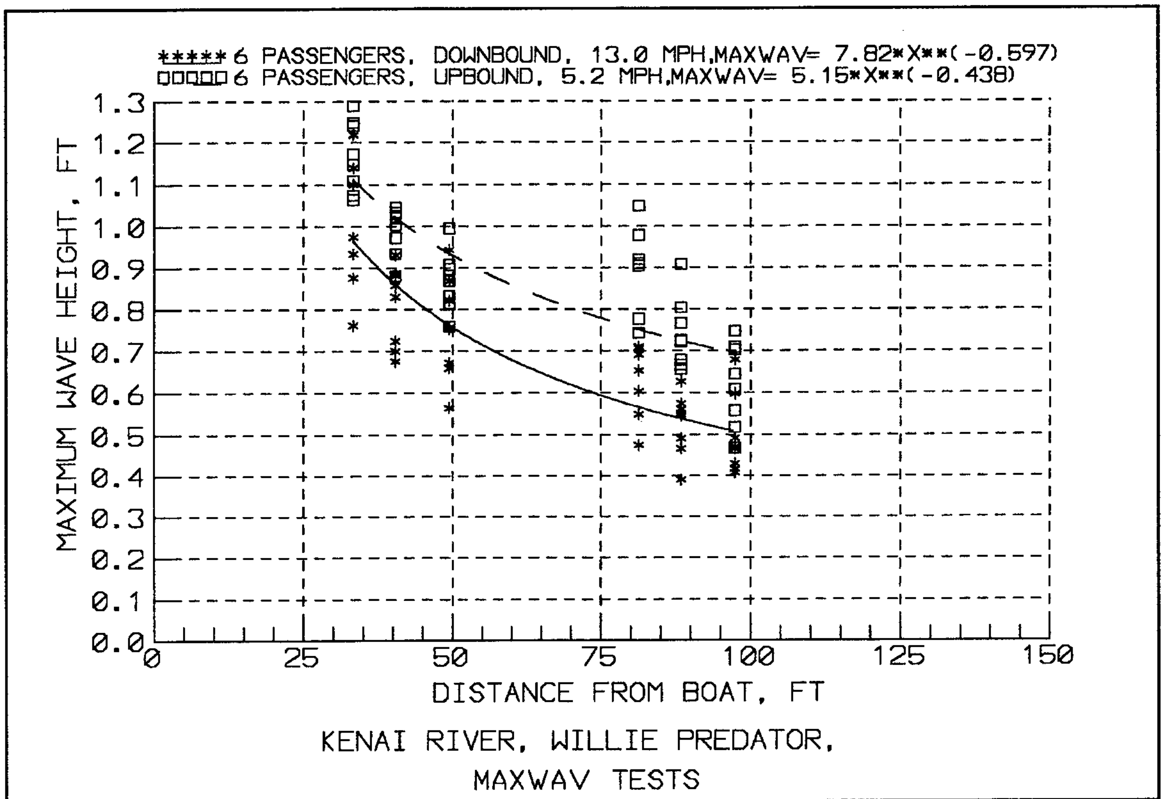
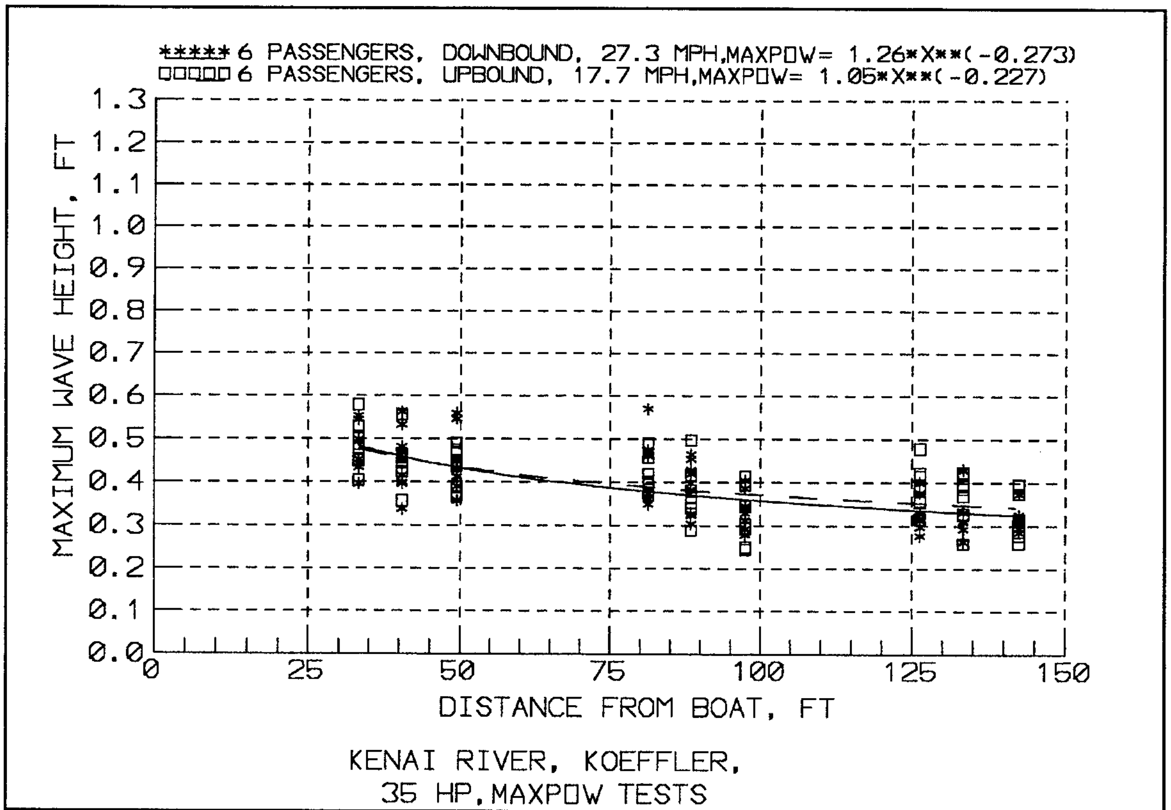
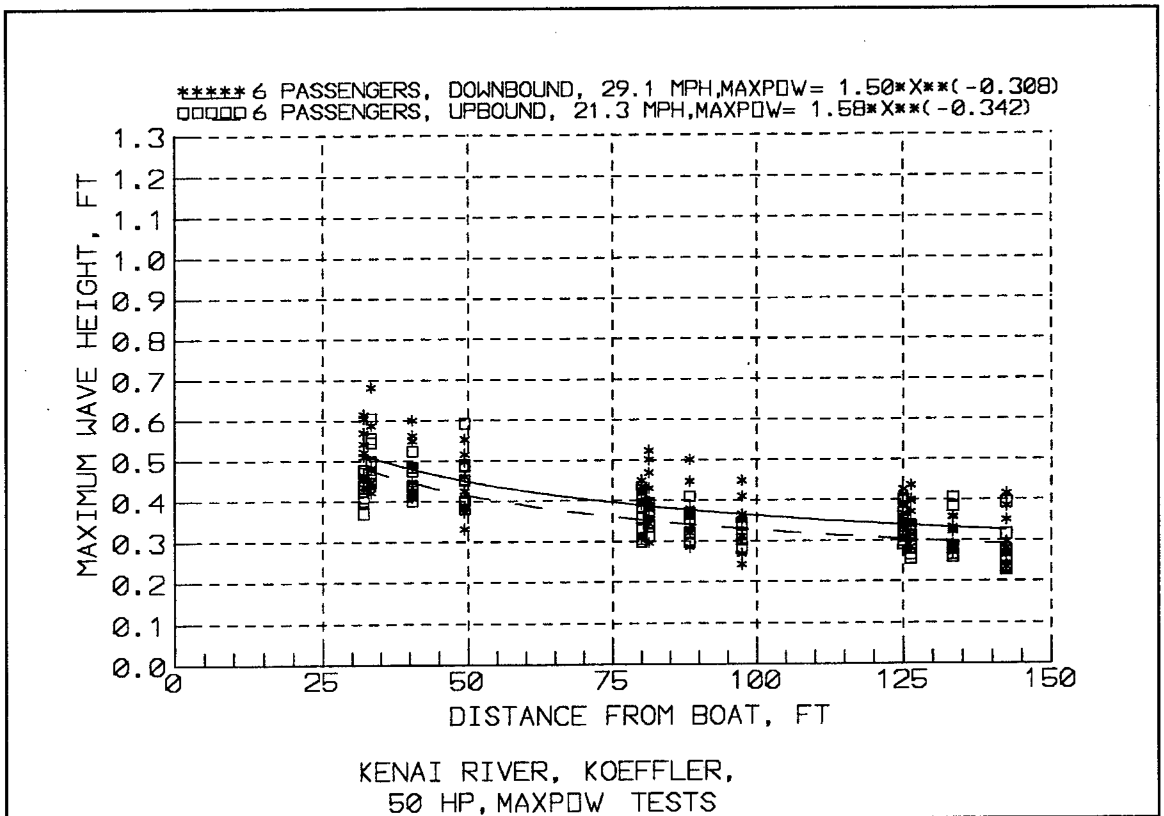

*****6 PASSENGERS, DOWNBOUND, 13.0 MPH,MAXWAV= 7.82*X**(-0.597)
□□□□□6 PASSENGERS, UPBOUND, 5.2 MPH,MAXWAV= 5.15*X**(-0.438)
MAXIMUM WAVE HEIGHT, FT
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
KENAI RIVER, WILLIE PREDATOR,
MAXWAV TESTS

Plate 23



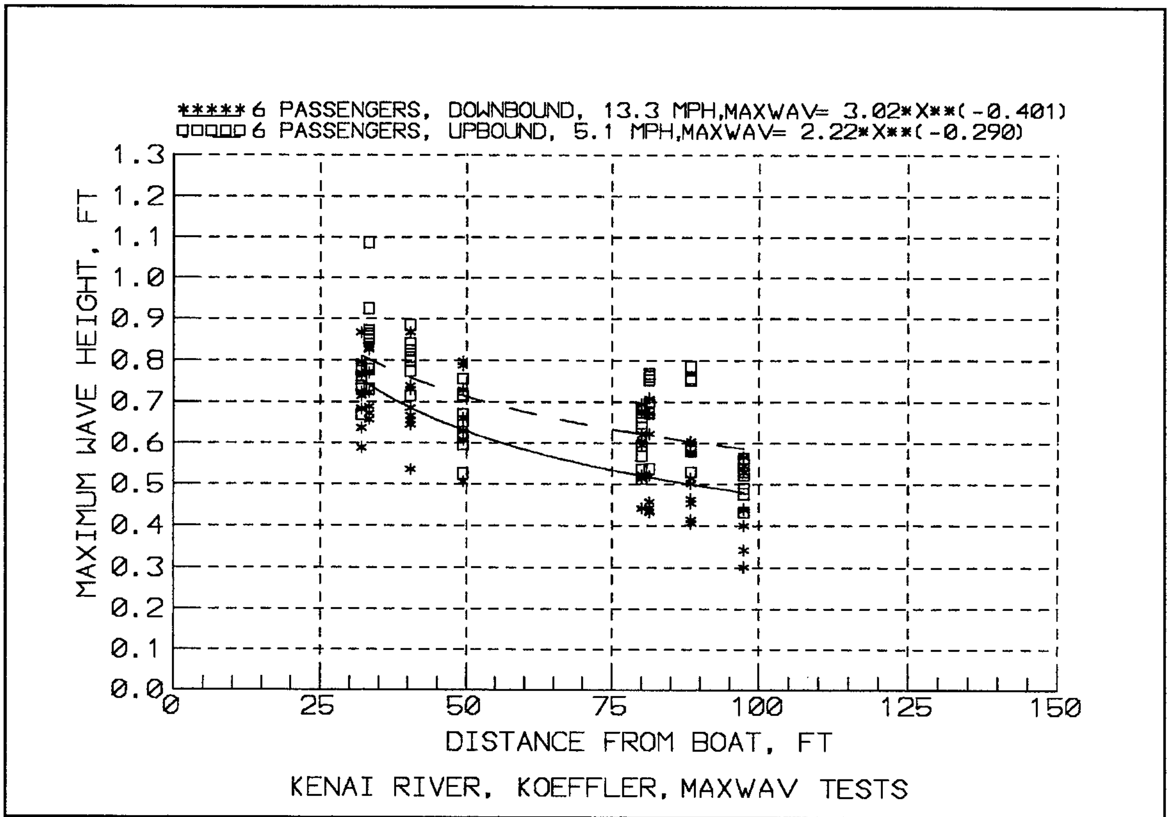
*****6 PASSENGERS, DOWNBOUND, 27.3 MPH,MAXPOW= 1.26*X**(-0.273)
□□□□□6 PASSENGERS, UPBOUND, 17.7 MPH,MAXPOW= 1.05*X**(-0.227)
MAXIMUM WAVE HEIGHT, FT
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
KENAI RIVER, KOEFFLER,
35 HP,MAXPOW TESTS

Plate 24



*****6 PASSENGERS, DOWNBOUND, 29.1 MPH,MAXPOW= 1.50*X**(-0.308)
□□□□□6 PASSENGERS, UPBOUND, 21.3 MPH,MAXPOW= 1.58*X**(-0.342)
MAXIMUM WAVE HEIGHT, FT
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
KENAI RIVER, KOEFFLER,
50 HP, MAXPOW TESTS

Plate 25



*****6 PASSENGERS, DOWNBOUND, 13.3 MPH,MAXWAV= 3.02*X**(-0.401)
□□□□□6 PASSENGERS, UPBOUND, 5.1 MPH,MAXWAV= 2.22*X**(-0.290)
MAXIMUM WAVE HEIGHT, FT
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
25
50
75
100
125
150
DISTANCE FROM BOAT, FT
KENAI RIVER, KOEFFLER, MAXWAV TESTS

Plate 26

REPORT DOCUMENTATION PAGE

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Stephen T. Maynord

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14. ABSTRACT

The Kenai River is Alaska's most popular salmon sport fishery and is located on the Kenai Peninsula south of Anchorage. The State of Alaska and U.S. Army Corps of Engineers (USACE) are concerned about bank erosion from the combined effects of the high summer flows and the high volume of boat traffic related to the salmon. The State of Alaska selected four boats typically found on the river which were 16-20 ft in length, carried up to six people, and were restricted to a maximum engine power of 35 hp for safety reasons. Boat wave measurements were conducted to determine wave characteristics as a function of hull type (flat or V-bottom), boat length, engine power, passenger loading, distance from the boat, and upstream versus downstream boats. Since some of the boats when fully loaded were just barely planing, the study sponsors wanted to know if increasing the allowable engine power from 35 hp to 50 hp would result in lesser wave height. Tests were conducted at both Johnson Lake and on the Kenai River. The measurements showed that significant reduction in wave height could be achieved by using flat-bottom boats, setting a minimum limit on the ratio of power to total boat weight, and limiting boat operation at nonplaning speeds that caused the largest waves.

15. SUBJECT TERMS

Bank erosion
Boat wake
Boat waves
Recreational boats
Salmon
Ship waves

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